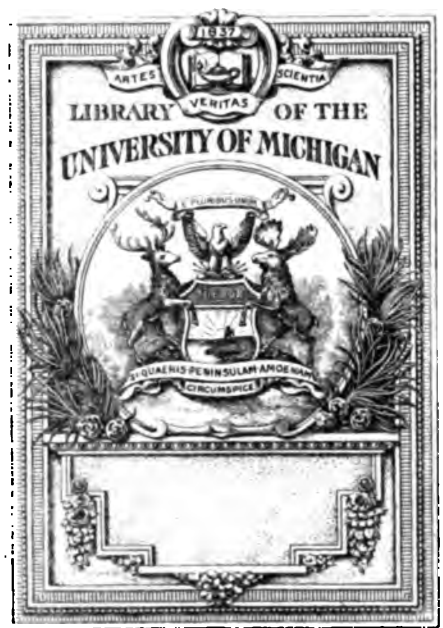
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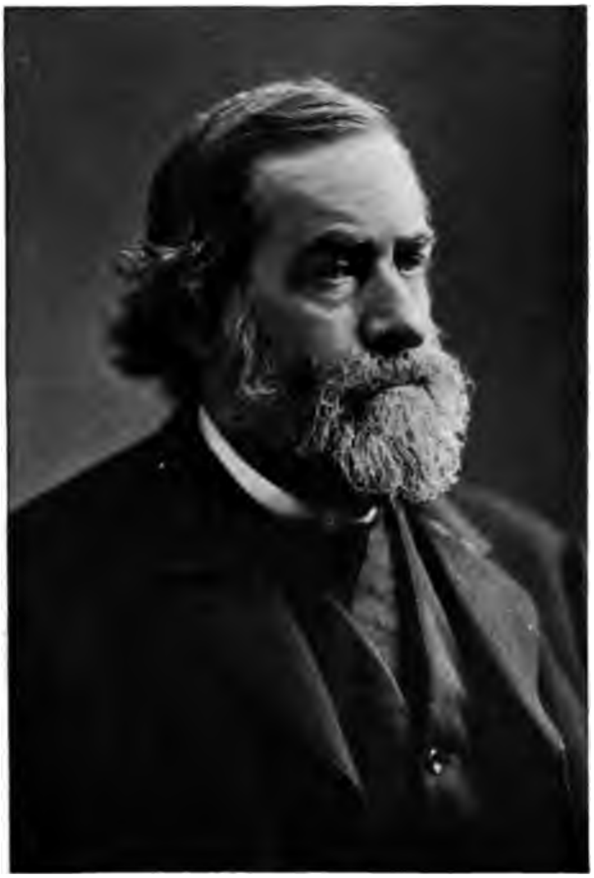
Vol. VIII., page 353, eighth line form the bottom, for "costal" read coastal.

Vol. VIII., page 279, fourteenth line from the bottom, for "was" read were.



Joseph Leidy

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Vol. IX, Plate I.

THE

AMERICAN GEOLOGIST

VOL. IX. JANUARY, 1892. No. 1.

JOSEPH LEIDY, M. D., LL.D.

By PERSIFOR FRAZER, Philadelphia.

There is no more striking difference between the past and present generations of scientific men than the universality of the knowledge of the greatest men of the past and the absence of any pretension to it in our present representatives. It could not be otherwise. In classic times as well as in the middle ages the distinction between words and things was not always clearly made. The same class of mind which would successfully grapple with the paradoxes of the schoolmen was equally serviceable in speculations on the philosopher's stone, the existence of phlogiston, or the interpretation of a Greek text. Words were all important, the methods of logic were conventional, and no extraordinary memory was required to master at least in outline all that man had attained: while the discussion of this knowledge could always be turned into the channel of the then philosophy, after which the battle was entirely with words and a skillful word-fencer could never be silenced however little progress he made in convincing his opponent.

With the closing half of the last century, however, methods were improved, the number of facts increased in geometrical progression with the years, and out of chaos and clamor, orderly classification and definite shapes were evoloved, each one requiring a different interpretation, claiming different classes of men, and requiring different instruments of precision. As the paths of research diverged it became more and more difficult for any one man to understand all the regions through which they passed, and one by one the philosophers became specialists. In the early part of this century the enormous development of natural and ex-

perimental science caused the strain ever to increase on those who would keep abreast of all departments of research, but still there remained the Humboldts, the Herschels, the Faradays, the Regnaults, and in this country the Baches, the Lecontes, the Leidys and some others. Joseph Leidy was almost the sole survivor of that class of intellectual giants which seemed to be able to assimilate as much as Science in her many forms could produce. Such a race could not exist forever and it has passed away with him. After him there are only specialists in one or more subjects, and generalizers who seldom come nearer to the truths of nature than their description in a book

The father of Joseph Leidy, Philip, was born in Montgomery county (one of those adjacent to the county which is the city of Philadelphia), December 5th, 1791 and moving in his youth to Philadelphia successfully pursued the business of a hatter.

By Catherine Melick he had four children of whom the subject of this sketch was next to the youngest. Through the death of his mother and the marriage of her sister by his father during his early infancy, Joseph only knew this kind stepmother who was as watchful of him as his real mother could have been. He was educated at private schools and early evinced interest in natural objects and exhibited that talent for drawing of which he made such admirable use to the last period of his life. An accidental opportunity to visit a drug shop, was taken advantage of by him to perfect himself in pharmacy in a very short time, while the dissection of some domestic animals turned his attention to a study which he was destined to link closely with his name. He began the study of medicine in 1842, in the University of Pennsylvania at 19, and in 1844, received the degree of M. D., and in 1845 was appointed Prosector to the chair of Anatomy, under Prof Horner In 1848 he went to England, France and Germany with Dr. Horner, and again in 1850 with Dr. George B. Wood.

He had been elected a member of the Boston Society of Natural History, and the Academy of Natural Sciences in Philadelphia in 1845, and of the American Philosophical Society in 1849 In 1852 he was appointed in Dr. Horner's place professor of anatomy having been elected to the College of Physicians the year previous On the outbreak of the civil war he was appointed [illegible] of the Satterlee hospital in Philadelphia. In 1864 he [illegible] Anna Harden. During the succeeding years, thickly [illegible] with contributions to science of the highest value, he re-

ceived many honors from American and European scientific so cieties. The long list of them will be found in the careful and admirable memoir of Dr. H. C. Chapman in the Proceedings of the Academy of Natural Sciences for June 30, 1891, to which I am indebted for the statistical information as to his early life given above.

Among these honors, however, his unanimous and enthusiastic election as President of the Academy of Natural Sciences in 1881; his installation as Director of the Biological department of the University of Pennsylvania in 1884; his election as President of the Wagner Free Institute of Science; and the degree of LL. D., which he received from Harvard in 1886; the gift of the Walker prize of $500 from the Boston Society of Natural History raised to $1,000 as a special recognition of his great services to science; the prize of the Royal Microscopical Society in 1879; the Lyell medal by the Royal Geological Society in 1884; and the Cuvier medal from the Academy of Sciences in Paris in 1888 should not be forgotten.

Dr. Leidy was elected a member of the National Academy of Science in 1884.

The bare enumeration of his published works extensive in length and in variety though it be, would give those who had never seen this great naturalist no idea of the man or of the source of this combination of versatility and accuracy which rendered almost every observation he made directly or indirectly an addition to science. In all that pertained to the acquisition of facts and to coördinating them afterwards he made of himself a perfect machine in so far as he was insensible to and unaffected by the ordinary passions of ambition or rivalry which influence even the best scientists. He had a marvellous eye for noting the minutest phenomena and appreciating the most insensible differences; he had an unusually retentive memory for recording and keeping in order the vast fund of his observations and the records of those made by others; and he was conscious of the limitations of pure inductive philosophy to an extent which made the conclusions reached by him safe. It is usually said that he never made an enemy. This seems to be too much to say, for enemies are made by the very fact of superiority, and no doubt this great man had them, but if so they were prudent enough to refrain from declaring themselves. He would never quarrel, and his desire for peace at all hazards would have subjected a less earnest

and pure minded man to the charge of lack of tenacity, but those whose cause he refused to espouse although he thought it just, gave him credit for a higher motive for his action. As an instance of the extreme delicacy of his vision, by a single glance through a glass case in one of the great University museums of this country he detected as imitations a number of specimens of so-called quartz which had been purchased, examined, and mounted by the professor of mineralogy as genuine. When these specimens were removed from the case and carefully tested it was found that those and only those which he had indicated were artificial.

He has told us of the prosecution of his study of Rhizopods when he expected an Amœba-like mass to break into two, or an enveloped diatom to be extruded, and the patience and endurance required to keep the eye at the instrument for hours waiting for a change that would occupy but a few seconds. He would wait and would see the phenomenon while a student with much more time at his disposal would have grown tired and missed it.

In the Brazilian department of the Centennial Exposition were many valuable tourmalines, diamonds, topazes and beryls together with a large amount of nearly worthless material. This was put into the hands of the writer for determination and arrangement. He well remembers the glance of Dr. Leidy at a large mass labeled beryl and his suggestion that it be more closely examined to determine if it were not a white topaz. The size of the specimen as well as its color had deceived the American geologist who had shipped it from Brazil, and the writer. But subsequent investigation proved it to be in fact a white topaz and the largest then known.

Dr. Leidy was a rare example of a simplicity of character which neither adulation nor adversity could tarnish.

In his very early life a less sincerely devoted student of science would have had his head turned by his rapid promotion, by the unusual confidence and liking of his superiors, and most of all by the extraordinarily flattering attention of the social world, but he was not spoiled. He probably noted his sensations on those occasions as so many psychological experiences.

Scientific men in all countries, very generally despise conventionalisms of dress, conversation, and carriage and there is a certain external resemblance between them all. Dr. Leidy was one of the best American representatives of the scientific class in all these respects. A splendid head with kind expression, set upon broad stooping shoulders, a deep chest to which an arm generally pressed

books or papers while the other hung free at the side; a straight toed walk with a sailor's swing from one side to the other at each of his long and easy strides; these things made him noticeable anywhere. People who knew him but slightly would go out of their way to wish him good morning, and would feel a touch of satisfaction at receiving his always hearty response. There is a beautiful conservatory in Philadelphia, on Chestnut street, near Twelfth, where he often stopped to admire the exquisite flowers which the generous owners expose to the delectation of their fellow citizens. The lucky acquaintance who joined him at such times was treated to an exposition of the peculiarities and beauties of the various flowers which ran as smoothly and unconsciously from him as if he were simply discussing the weather, but which opened new vistas of admiration, both of him and of the works of nature in his listener.

For years he was accustomed to pass a part of every Sunday in the mineral cabinet of the late Richard L. Vaux and after Mr. Vaux's death in that of Mr. Clarence Bement. Many were the unsound determinations set right and many the fruitful discussions over minerals and everything else.

Like the true naturalist that he was, he bequeathed his body to his colleagues in the interest of amthropometric science, his friends and pupils Dr. Harrison Allen and Dr. Francis X. Dercum having extracted, weighed, measured and preserved that wonderful brain. His remains were cremated, and thus passed from earthly form one of the loveliest, wisest, and gentlest of men. May his example be of service to us all.

NOTE:—Since writing the above I am indebted to the nephew of the subject of this sketch, himself an eminent physician, for the following additional facts:

* * "The weight of the brain was 45½ oz., somewhat smaller than normal, and the appearance of the surface presented an unusual increase in the convolutions. No microscopic examination has as yet been made. The points of pathological interest were the presence of a hemorrhagic pachymeningitis on the right side and an unusual hardness of the blood vessels at the base due chiefly to atheroma. By a singular coincidence the brain of my father (Dr. Philip Leidy who died within a few hours of his brother, P. F.) weighed exactly the same to a grain and presented very much the same microscopical appearance, showing a decided family trait. They both suffered from anurism, Dr. Joseph Leidy of the aorta and Dr. Philip Leidy of the heart. In all my experience, which has been large, at the post mortem table, I never saw the blood vessels at the base of the brain so large and hard. They were typical pipe stems."

In a subsequent note, he adds: "Dr. Harrison Allen assisted by Dr. Dercum, as representatives of the anthropomoric society, performed the autopsies in both cases. Drs. Wm. Hunt, J. J. Levick, John Packard and Joseph Leidy, Jr. (the writer P. F.) were present. * * Both bodies were cremated in the Germantown crematory."

THE CHEMUNG AND CATSKILL (UPPER DEVONIAN) ON THE EASTERN SIDE OF THE APPALACHIAN BASIN.

By JOHN J. STEVENSON, New York.

[Vice-Presidential address delivered before Section E, American Association for the Advancement of Science, at Washington, August, 1891.]

I have chosen as a topic, the Chemung and Catskill on the eastern side of the Appalachian basin, indicating by this term the area between the Blue Ridge region at the east and the line of the Cincinnati uplift at the west. It embraced as a water-area during the later Devonian much of New York, Pennsylvania, Ohio, Virginia, West Virginia and eastern Kentucky. There is reason for the belief that the southern outlet through eastern Tennessee was closed during this time, so that communication with the ocean was at the west.

The Upper Devonian on the eastern side of this area has always attracted its full share of attention. Palæontogically, it has intimate relations with the Lower Devonian and in some respects close relations with the Carboniferous, so that its place in the column remains even now, for some, an open question. The equivalence of Upper Devonian within the Appalachian basin to that beyond the line of the Cincinnati uplift is still a sufficiently perplexing matter; while the origin and grouping of the beds within the basin itself are far from being finally settled.

The earliest positive reference to the Old Red sandstone is that by Amos Eaton,* who in 1821 regarded the red sandstone of the Catskill mountains as typically the same with the Old Red sandstone of Werner and as distinctly different from the Red sandstone of the Connecticut Valley; at the same time recognizing its relations with the Carboniferous and placing it in the Transition series.

Marcou states† that Richard C. Taylor published a paper in 1831, discussing the relations of the Old Red sandstone to the Carboniferous; the same author‡ in a later paper exhibits clearly the place of the Red sandstone in central Pennsylvania and its relations to the overlying Carboniferous. He appears to include

*Memoirs of the Board of Agriculture of the State of N. Y., vol. II, Albany, 1823, p. 6. The letter to Mr. Van Rensselaer is dated Dec. 17th, 1821. A similar reference was made in a Geological and Agricultural Survey of the District adjoining the Erie Canal, Albany, 1824, p. 92.

†Geology of North America. Zurich, 1858, p. 114. This paper by Taylor I have not seen.

‡Taylor. Transactions of the Geological society of Pennsylvania. Phila. 1835, vol. 1, p. 177.

it in the Secondary with the coals west of the Alleghanies, thus separating it from the graywackes below.

The first systematic classification of American rocks older than Carboniferous was presented in 1836 by H. D. Rogers,* who placed in two groups the beds between the "fossiliferous sandstone," (or Oriskany, as we now know it) and the Lower Carboniferous sandstone (Vespertine or Pocono of later classifications.) These groups, Nos. VIII and IX of his column were distinguished from the Carboniferous, which he divided into four groups, afterwards numbered X, XI, XII and XIII. The same classification, with rather more of detail, was repeated in the Second Pennsylvania report†, as well as in the Second Report of W. B. Rogers‡ on the survey of Virginia.

No distinct effort to subdivide the upper portion of the Devonian column of New York was made prior to preparation of the Third Report of the Geological Survey. In that report Mr. Conrad§ defines the "Old Redstone Group (Murchison)" as embracing

9. Olive sandstone.—Old Red sandstone ?
8. { Dark-colored shales.
   { Black slate.

thus carrying it down to the base of the present Hamilton. In the same report, James Hall‖ introduced the term "Chemung" for gray beds in Chemung county, overlying those of his Ithaca group.

The fourth report contains Vanuxem's description¶ of the series in his district, giving a complete grouping of the higher rocks and placing the Montrose or Oneonta sandstone at the top of the column. The same report contains the general classification by Prof. Hall** in which the terms, Old Red sandstone, Chemung group, Portage group occur in the order given. One year later Mather†† used the term "Catskill Mountain Series" to designate all the rocks of the Catskill mountains from the Lower Carboniferous sandstone (Pocono) of Rogers down to the base of

*First Annual Report of State Geologist, Harrisburg, 1836, pp. 12 to 15.

†Second Annual report on the Geological Exploration of the State of Pennsylvania, by H. D. Rogers, Harrisburg, 1838.

‡Second Report of Progress of the Geological Survey of Virginia for the year 1837. W. B. Rogers; 1838, pp. 75-80.

§Assembly Document, No. 275, Albany, 1839, p. 72.

‖Loc. cit. p. 322. ¶Assembly Document, No. 50, 1840, p. 381.

**Loc. cit. pp. 452-453.

††Assembly Document, No. 150, 1841, pp. 77-82.

the Marcellus shale, thus making it equal to Formations VIII, IX and X of the Pennsylvania column. The term Catskill group appears for the first time in Vanuxem's[*] final report, where it is used to designate the rocks at the top of the Devonian, which are regarded as fully equalling in importance the underlying Chemung and Hamilton, forming his Erie division; so that the Erie and Catskill are equivalent to the VIII and IX of Rogers. No line of demarcation between Erie and Catskill was determined.

Hall's[†] final report appeared one year later and contained the grouping which has remained unchanged:

Old Red sandstone or Catskill.
Chemung group.
Portage group.

Fifteen years later appeared the final report on the Geology[‡] of Pennsylvania, in which Chemung and Portage are called Vergent, and the Catskill is the Ponent of the palæozoic column. This report took shape long after the original corps of observers had been scattered and the field-note books were not worked up in all cases by those who had made them, so that the statements are sometimes obscure and local details are too often perplexing to readers not familiar with the ground. Little additional systematic information became available after the publication of Rogers' final report until the results obtained by the Second Geological survey of Pennsylvania became known.

The studies by assistants on the Second Pennsylvania Survey were very much in detail owing largely to the immense economic importance attaching to the upper portion of the Devonian column. But this detailed study, though leading to close concord in record of stratigraphical work, has led to wide difference of opinion in respect to lines of separation between the groups. As the area of Pennsylvania is large, great variations exist in physical characters of rocks and in vertical distribution of fossils, so that difference of opinion arose to a greater or less degree respecting the limitations of every group, but the difference is especially noteworthy in the case of Catskill and Chemung, for one observer carries the upper boundary line of Chemung almost 2,000 feet further up in the column than is done by another

*Geology of New York, part III, Albany, 1842, p. 12.
†Geology of New York, Part IV, Albany, 1843 pp. 18-19.
‡Geology of Pennsylvania, H. D. Rogers, Philadelphia, 1858.

One observer coming from the northeast along the easterly outcrop of the Devonian finds good reason to mark Catskill as beginning with the first appearance of red shales, while another coming from the west and south thinks that Chemung should close only with the final disappearance of the marine fauna. When these observers joined their work, their sections were in practical agreement, but were labeled very differently.

The uncertainty respecting the relations of Chemung and Catskill is due in no small degree to the fact that the earlier studies of those groups were made in New York and adjacent portions of Pennsylvania, without much knowledge of the conditions elsewhere. Had the study been begun at the south in Virginia, then carried northward along the easterly outcrop through Virginia, Maryland and Pennsylvania into New York; then begun again in western New York or Pennsylvania and carried eastward to the outcrop, many difficulties, now apparently so formidable, would have been unknown and the problem of relations, seemingly so perplexing, might have been easy of solution. At this time, however, the study can be prosecuted to better advantage than was possible even ten years ago, for the oil-borings of western Pennsylvania enable one to trace the beds through that region also, where in some localities they are more than 2,000 feet below the surface. Let us follow, then, the courses indicated, depending on the work of I. C. White, J. H. Carll and C. A. Ashburner in Pennsylvania, and that of J. J. Stevenson in Virginia and Pennsylvania, with references to the work of James Hall and H. S. Williams in New York.

II.

In the southwestern portion of Virginia, near the Tennessee line, the Devonian is represented only by black shale,* belonging at the base of the Hamilton; but within a few miles the Hamilton shows a greatly increased thickness,† while between it and the Lower Carboniferous there are 350 feet of rock carrying Chemung fossils to within fifty feet of the top. The fossils are most abundant in a red or bluish rock with conchoidal fracture, which is the same in all respects, physically, with some non-fossiliferous

*Stevenson, Proc. Amer. Phil. Soc. vol. XIX, pp. 223, 233, 243.
†Stevenson, Proc. Amer. Phil. Soc. vol. XXII, p. 136.

beds higher up in the section. Within sixty miles along the strike, this 350 feet has developed into a great series with well marked horizons in the lower part,* while the upper part has become flaggy with not a few massive beds. The succession now is, the thicknesses being estimated,

1. Not fully exposed, containing much red sandstone	700′
2. *Conglomerate*	40′
3. Shales and sandstone	1,000′
4. *Conglomerate*	30′
5. Shales and flags	1,500′

But the No. 1 of the section contains gray beds in the lower portion, which, in some localities, have yielded Chemung mollusks at not less than 300 feet above the conglomerate, while on New river, Va., where the thickness is somewhat greater, Chemung forms were seen at about 500 feet above the conglomerate. But the reddish beds which prevail toward the top seem to be non-fossiliferous. The tint of these beds becomes more and more pronounced toward the northeast, until in Catawba mountain, somewhat more than twenty miles southwest of James river, they have the dismal red and greenish color, so characteristic of the series along the Potomac. And yet, in McAfee's gap, only eight miles northward, *Spirifera disjuncta* and some other Chemung forms occur very near the top of the series, within a few feet of the Vespertine (Pocono) sandstone.

The other parts of the section can be observed at many places; the upper conglomerate (No. 2) contains flat pebbles, which frequently show the longer axis vertical to the plane of bedding; No. 3 contains concretionary sandstones passing downward into shales, with brown, blue and red to deep red flags and flaggy sandstones. Chemung mollusks are especially abundant near the top. The lowest division consists of flags and shales, olive, gray, yellow, blue and drab, with but few fossils.

This is the section to James river, somewhat more than 150 miles from the Tennessee line. Details of measured sections made in recent years between the James and Potomac rivers, a distance of not far from 200 miles, have not been published; but we need not wait for detailed measurements in this interval. Observations by the writer and by others at many localities have proved the section persistent; and the same succession

*Stevenson, Amer. Phil. Soc. Proc. vol. XXIV, p. 81 seq.

is shown along the Baltimore and Ohio railroad as it follows the Potomac river. Of course there are variations in structure; Mr. N. H. Darton tells me that the conglomerates are wanting in the section near Staunton, Virginia, but this is merely local as they are present elsewhere. Further north, the upper beds, or Catskill, have an increased proportion of shale, often blood-red, and the sandstones show a more marked conchoidal fracture, while the whole section has a greatly increased thickness.

The Pennsylvania line is reached but a few miles north from the Potomac along the outcrop. Crossing that line, one enters Fulton county, where the succession is:*

1. CATSKILL.	Shales	1,600′	
	Sandstone and shale	2,100′	3,700′
2. CHEMUNG.	Shales	1,000′	
	Upper conglomerate	10′	
	Shales and sandstone	950′	
	Lower conglomerate	10′	
	Shales and flags	1,850′	3,820′

The close resemblance to the Virginia section is apparent at once, the most notable change being simply the great increase in thickness of the upper portion. The upper Catskill consists for the most part of soft deep red shales with occasional sandstones; but the lower Catskill is made up of brownish or greenish to red, cross bedded, almost laminated sandstone, often looking as though it were worm eaten. Sometimes a large fragment remains on a hill top, resembling much a pile of thin boards. Occasionally more massive sandstone prevails, as along the Juniata river in central Bedford county of Pennsylvania, where no tendency to lamination was seen. The Catskill appears to be wholly non-fossiliferous along the eastern outcrop from central Virginia into New York.

The absolute limit between Catskill and Chemung is indeterminable, for the passage from one to the other is practically imperceptible at most localities; the line drawn at any locality, whether on stratigraphical or on palæontological grounds, is almost certain to be unsatisfactory at any other. In Fulton county, however, a marked lithological change occurs at about 1,000 feet above the Upper Chemung conglomerate, for there the alternations of red

*Geology of Bedford and Fulton counties, J. J. Stevenson, Harrisburg, 1882, pp. 73, 75, 82. I have re-arranged the section somewhat, placing the line between Chemung and Catskill 200 feet higher than in the original.

and yellow shales cease and the flaggy, almost laminated, red sandstones begin. The last horizon of Chemung mollusks was found at 200 feet lower, where, at approximately 800 feet above the conglomerate, the writer orginally drew the line between the two groups.

The interval between the conglomerates is filled with yellow to red shales and gray, brown, blue or red sandstones; the red beds form an insignificant portion of the section, but such as are present are strikingly like Catskill, for the shales are often bright red and the sandstones cross bedded or in thin flags. Many of the beds in this interval are richly fossiliferous and the important horizons of Chemung lamellibranchs are at but a little way below the upper conglomerate. The lowest beds of the Chemung are shales and flags; the shales overlying the flags are yellow, gray, olive, dark brown and reddish; while the flags, which doubtless represent the Portage of New York, are almost wholly olive, and, unlike the overlying shales, appear to be very sparingly fossiliferous.

Beyond Fulton county northward into New York, we must depend almost wholly upon the work of Prof. I. C. White, who has demonstrated the stratigraphical relations of the beds under consideration to those of the Catskill area of New York, and has told the story with such clearness that there is no opportunity for any one to cavil. His grouping of the rocks, however, differs from that already given; he prefers to include as Catskill all beds down to 100 feet below the upper conglomerate, which is the lowest horizon at which he found fish remains; he regards as transition the beds below that fish bed to the lowest red bed, 150 feet above the lower conglomerate, and applies to them the term Chemung-Catskill; while the remaining beds of the section are taken by him to represent the Chemung and Portage of New York. He identifies the Upper Chemung conglomerate of Fulton county with his *Lackawaxen* conglomerate of the New York border and he gives the name of *Allegrippus* to the lower conglomerate.

The succession in Huntingdon county, Pennsylvania,* is :

*I. C. White in Geology of Huntingdon County, Harrisburg, 1885, pp. 92-104. As given here Nos. 1, 2, and 100 feet of No. 3, of the Chemung belong to Prof. White's Catskill; the rest of No. 3, except 150 feet at the base forms the Chemung-Catskill of the same author. All sections along this outcrop, quoted from Prof. White, have been re-arranged in this way.

1. CATSKILL.			2,500′
2. CHEMUNG.			
	1. Haun's Bridge group	1,000′	
	2. *Lackawaxen* conglomerate	20′	
	3. Sandstones and shales	1,000′	
	4. *Allegrippus* conglomerate	5′	
	5. Shales and flags	3,250′	4,675′

The Haun's Bridge group consists largely of greenish gray sandy shales and flags with some red beds, and holds from bottom to top Chemung mollusks, some of which are very abundant.

Prof. White's measurements near Catawissa, in Columbia county, Pennsylvania, about sixty miles further along the strike, show the section still persistent, the succession being:*

1. CATSKILL,			3,230′
2. CHEMUNG.			
	1. Shales and sandstones	923′	
	2. *Lackawaxen* conglomerate	40′	
	3. Shales and sandstones	1,180′	
	4. *Allegrippus* conglomerate	10′	
	5. Shales, sandstones and shaly beds	2,300′	4,453′

The Catskill exhibits little change in structure and, as before, appears to have no fossils aside from obscure fish remains. No. 1 of the Chemung is the same with the Montrose shales of Susquehanna county as well as the Haun's Bridge group of Huntingdon county. It consists, as it does further south, of variegated shales and sandstones, green and red predominating, and in the lower half has many beds carrying Chemung mollusks. I have drawn the line between Chemung and Catskill somewhat arbitrarily, where sandstone ceases to predominate, for there is no noteworthy physical change in character of the rocks anywhere above the *Lackawaxen* conglomerate. That conglomerate is now irregular in structure, sometimes not conglomerate, but still containing fish-bones as it does further south. The fragments of bones are larger and in better preservation than at the more southern localities.

The interval between the conglomerates contain some red beds but as usual they form only a small part of the section, little more than ten per cent of the whole. A bed containing fragments belonging, apparently, to *Holoptychius* associated with *Pleurotomaria* sp. and *Lingula spatulata*, was observed at 150 feet below the *Lackawaxen* conglomerate. Vegetable remains

*The Geology of the Susquehanna river region, I. C. White, Harrisburg, 1883, p. 57.

are not wanting, for *Archaeopteris hybernica* is abundant above the fish bed. The *Allegrippus* conglomerate is no longer a constant member of the series, though occasionally it is recognizable without difficulty as a massive sandstone, sometimes containing flat pebbles.

Thus far, the section observed beyond the James river in Virginia has been persistent, the distance along the line of outcrop being not far from 500 miles. In Columbia county, however, the interval between the conglomerates is no longer richly fossiliferous, while fossils reach to but 516 feet above the *Lackawaxen*, instead of to 1,000 feet as in Huntingdon county. The section is still sufficiently distinct at Hartville,* Luzerne county, Pa., about twenty miles further along the strike; but thence northeastward changes in structure become marked and are accompanied by a still more rapid disappearance of animal remains, so that within a few miles such remains seem to be almost wholly wanting in beds above the place of the *Allegrippus* conglomerate.

Prof. White's Pike county section was measured along the Delaware river about fifty miles northeastward from the Catawissa locality and practically on the same line of outcrop. It illustrates the conditions in New York for the Delaware river there cuts across the Catskill mountain region. The succession is†:

CATSKILL.			
	Honesdale sandstone	100′	
	Montrose sandstone	125′	
CHEMUNG.			
	1. Montrose red shale	100′	
	2. Greenish-gray sandstone	30′	
	3. *Lackawaxen* conglomerate	50′	
	4. Greenish sandstone and shale	300′	
	5. Red shale	50′	
	6. Delaware flags	1,000′	
	7. New Milford shales and S. S.	75′	
	8. Starucca beds	600′	
	9. Sandstones and sandy shales	1,850′	4,055′

The highest beds of the Catskill, the Cherry Ridge shales, were not measured, but they add barely 150 feet, so that, within little more than fifty miles, the Catskill has lost almost 3,000 feet, while the Chemung is but 400 feet thinner. But it should be noted that the upper portion of the Chemung has lost much, while the lower portion has increased greatly. The *Allegrippus*

*White, Loc. cit. p. 196.

†Geology of Pike and Monroe counties, I. C. White, Harrisburg, 1882, pp. 73 and 94.

conglomerate belongs at the base of the Starucca beds but it is not present. Even the *Lackawaxen* is no longer persistent as a conglomerate and in some localities it is not even massive.

The most interesting feature of this section, characterizing also those obtained along fragmentary outcrops in Carbon and Monroe counties, say 25 miles southeast of that which has been followed, is the apparent absence of animal remains from the whole series above the lowest member of the section, there being no trace aside from what seem to be fragments of fish-bones in breccias of the Honesdale sandstones.* *Archaeopteris jacksoni* is plentiful near the base of the Montrose shales.

We have followed this section along practically one line of outcrop for nearly 600 miles, from the northern boundary of Tennessee into southeastern New York. Its persistence, stratigraphically, is remarkable, since variations in structure are inconsiderable until within thirty miles of the New York border; but serious changes of some sort occurred during the long period of deposit, for in the extreme south, even the representative of the Montrose sandstone carries Chemung fossils, while in northeastern Pennsylvania and the immediately adjacent portion of New York, animal remains practically disappear above the horizon of the *Allegrippus* conglomerate.

Let us now return to southern Pennsylvania and follow the section westward; but first let us re-label the Fulton county section, giving to its parts the geographical names applied in the counties between that and the Delaware river, so that the relations of the different parts of the section may be remembered. It becomes

CATSKILL.		
Cherry Ridge shales	1600′	
Montrose sandstone	2100′	3700′
CHEMUNG.		
1. Montrose red shales	1000′	
2. *Lackawaxen* conglomerate	10′	
3. Shales and sandstones, including Delaware flags and Starucca beds	950′	
4. *Allegrippus* conglomerate	10′	
5. Shales and flags, including Portage of New York	1850′	3820′

The thickness of the section diminishes rapidly toward the west, so that on the western border of Bedford county, near the

*Mr. C. S. Proser informs me that he has discovered some lamellibranchs in the Delaware flags and some *Spirifers* in the Honesdale sandstone, or possibly at the base of the Cherry Ridge shale.

Maryland line, the Cherry Ridge shales have almost disappeared and the total thickness of Catskill, including doubtless some of the Montrose shale, is but 1980 feet. No outcrop is seen in the adjoining county of Somerset until the western edge has been reached, where under the great anticlinal of Laurel hill, the Youghiogheny river has cut down to the Delaware flags. There the Montrose sandstone is present, but only a few feet thick; while at not more than three miles further west, on the other side of the anticlinal, the Catskill has disappeared and the Vespertine (Pocono) rests directly on the Montrose shale.

The Chemung shows a similar decrease in the same direction; for on the railroad section in western Bedford, the whole interval of Chemung and Hamilton is represented by a concealed space* of 2,630 feet, giving to the Chemung a thickness of somewhat more than 1,800 feet. The exposures under Laurel hill in the Youghiogheny and Conemaugh gaps suggest a continuance of the decrease, certainly in the upper portion. The gaps through Chestnut ridge, ten miles west from Laurel, afford the last exposures, in this direction, of any part of the Devonian on the eastern side of the basin; the section in the Conemaugh gap, barely fifty miles in a direct line from Pittsburg,† is

Pocono	443′
Montrose red shales	125′
Lackawaxen conglomerate	20′
Shale and sandstone	120′
Concealed to river	150′

The Montrose shale is composed of dull, grayish-red shale and thin streaks of sandstone, carrying Chemung species up to within one foot of the Pocono. The Lackawaxen is characterized by flat-pebbles as it is also on the "National road" in Fayette county, where some of the larger pebbles are felsyte-porphyry.‡ Excavations made since these measurements were obtained show that there is much dull red shale below the *Lackawaxen*, especially in the concealed portion. The interval from the top of the Pocono

*Stevenson, Geology of Bedford and Fulton counties, p. 81.

†Geology of Fayette and Westmoreland Counties. J. J. Stevenson, Harrisburg, 1877, p. 291.

‡An annoying error occurs in my report on the Ligonier Valley (Harrisburg, 1878). Part of the notes referring to this rock were copied under the Pocono, and some of the Pocono transferred to this; so that this conglomerate is described as not containing flat pebbles.

to the *Lackawaxen* is 568 feet; in the deep boring at Pittsburg it is given as 519 feet.

Mr. J. H. Carll has tabulated the oil-well records in the western oil-bearing counties of Pennsylvania, and we must depend largely upon his work as we follow the series northward in western Pennsylvania; though one may sometimes fail to accept his identifications, yet all must acknowledge the patience with which he has worked and the excellence of his results.

At Washington, about thirty miles southwest from Pittsburg, the interval to the *Lackawaxen* is from the top of the Pocono is 518 feet, and the rock is termed by Mr. Carll, the "gas sand."*

The section there is

Pocono (Shenango sandstone of White)	152′
Interval	366′
Lackawaxen conglomerate	20′
Interval	87′
Gantz oil sand	40′

The Pocono has become less coarse. At Pittsburg it contains much shale, while in Washington county its sandstone is often less than 150 feet thick.

Mr. Carll recognizes in the Gantz sand, the upper or first of the Venango group of oil-sands, which consists of three well marked sandstones separated by shales and showing few variations in Venango county. It is not easy, however, to accept this identification after a careful study of his sections as tabulated in the Annual Report for 1886, and I am compelled to regard the upper gas sand of Weirick's well as the first oil sand of Venango, and as the *Lackawaxen*.† The distribution and variations of the Venango group are shown in the very numerous records of oil-wells which Mr. Carll has preserved and published in his volumes on the western counties of Pennsylvania. A section on Thorn creek‡ in Butler county, at about thirty miles northward from Pittsburg gives

Shenango sandstone (of White)	
Interval	395′
(*Lackawaxen*) first Venango oil sand	45′
Interval	420′
(*Allegrippus*) third Venango oil sand	46′

*Carll in Ann. Report of 2d Geol. Survey of Pennsylvania for 1886, p. 656. See plate Plate 5 figs. 20 and 21.

†See fig. 21 of Plate 5.

‡Carll in Report for 1886, p. 650. See Fig. 19 of Pl. 4. I have condensed the section and inserted the names of the sands.

Seven years ago Prof. White asserted that the first oil-sand is the same with his *Lackawaxen*, and suggested that the *Allegrippus* might prove to be the same with the third Venango. There is no room for doubt respecting the accuracy of these surmises. The interval between the sands is not far from what we should expect, for in western Bedford it is not more than 600 feet, and the decrease in the upper part of the column continues westward to the last exposure under Chestnut ridge. Some red rock occurs in this interval at Pittsburg and at Petrolia in eastern Butler as well as at Edenburg, 20 miles further east in Clarion county. Red shales, from 60 to more than 100 feet thick, overlie the *Lackawaxen* at many places in Butler county, though occasionally they are separated by a few feet of variegated shale. A section on Bullion creek,* in Venango county, about thirty miles north from Thorn creek, shows 100 feet of red rock immediately over the *Lackawaxen* or first oil-sand and 55 feet of red rock in the 215 feet interval between that and the *Allegrippus* or third oil-sand. The distance here from the Pocono to the *Lackawaxen* is 385 feet, almost the same as in Brady township and on Thorn creek of Butler county.

It is unnecessary to go into further detail respecting the features of the Venango group, as the variations, aside from those of thickness, are inconsiderable, and they are all shown in full in Mr. Carll's several reports.

The whole series comes to the surface again in Crawford and Erie, the northwest counties of Pennsylvania, where the subdivisions have been worked out in great detail by Prof. White. I give his generalized section† somewhat condensed and differently divided:

POCONO.			
	1. Shenango sandstone	25′	
	2. Meadville shale and limestone	66′	
	3. Sharpville flags and limestone	64′	
	4. Orangeville shale	75′	
	5. Corry sandstone	20′	
			250′
CHEMUNG.			
	1. Cussewago shale and limestone	37′	
	2. Cussewago sandstone	25′	
	3. Riceville shales	80′	
	4. [*Lackawaxen*] first oil-sand	20′	

*Carll in loc. cit. p. 647. See Pl. 3, Fig. 14.

†Geology of Crawford and Erie Counties. I. C. White. Harrisburg, 1881. pp. 66-119.

5. Shales with second sand	260′	
6. [*Allegrippus*] third oil-sand	30′	
7. Lower Chemung	325′	
8. Girard	225′	
9. Portage	475′	1477′

Prof. White placed the whole section to the base of the Cussewago in the Pocono or Lower Carboniferous, though seemingly with some hesitation respecting the lower members. The Corry sandstone appears to be the representative of the Berea of Ohio. The Riceville shales are equivalent to the red rock of Butler and Venango as well as to the Montrose red shales of the eastern sections. Typical Chemung forms occur here at many places up to within 15 feet of the Cussewago sandstone. The *Lackawaxen* is seldom coarse in northwestern Pennsylvania. The *Allegrippus*, or third oil-sand, is the persistent stratum in this region and the one possessing economic importance. Prof. White gives good reason for identifying it with the Panama conglomerate of New York. Prof. White found the same section in Warren county at Tidioute, twelve miles east from the Crawford line, and he regards the *Coccosteus* bed at Warren as the same with the *Lackawaxen*, or first Venango oil-sand. Mr. Carll's section at Great Bend,* on the eastern edge of Warren county is of interest as showing the appearance of the "Catskill type,"† as he terms it, there being above the Riceville shales, 88 feet of greenish gray sandstone with olive and red shales; so that somewhere between Tidioute and Great Bend the typically Catskill characteristics appear in the upper part of the section. Chemung fossils are found in the Riceville shales or Montrose Red shales and *Sanguinolites* occurs in the *Lackawaxen*.

Meanwhile a noteworthy change has occurred below the *Lackawaxen*, for though 327 feet of rock are shown, yet the *Allegrippus* or third sand is not reached; so that we are prepared for the condition shown by Mr. Ashburner's generalized section of McKean county, next east to Warren along the northern border of the state. There we find‡

Pocono	250′
Catskill	250′
Chemung	1990′

*Loc. cit. p. 641.

†Geological Report on Warren county, J. H. Carll, Harrisburg, 1883, p. 302.

‡Geology of McKean County, Etc. C. A. Ashburner, Harrisburg, 1880, p. 48.

the Catskill consisting of "red and grey slate, shale and sandstone" at Smethport, thirty miles east from Great Bend, in Warren county. The Chemung is triple, and its upper division is itself distinctly triple, consisting of

Gray shale and sandstone	350′
Red and gray shale and sandstone	300′
Gray shale and sandstone	650′

the lowest beds resting on the Bradford oil-sand, which is Mr. Ashburner's Middle Chemung. Typical Chemung mollusks occur in the highest beds of the Chemung and some species appear to have persisted into the lower portion of the beds assigned to the Pocono. This abrupt thickening of Chemung and Catskill is precisely what should be expected here to accord with the conditions along the southern border of the state.

The sections in Potter county, that adjoining McKean at the east, are incomplete, and our knowledge of the structure is far from being satisfactory. Mr. Ashburner made some examinations in the western part of the county, which were merely incidental and sufficed only to show that the "Catskill type" of rock increases in thickness eastward just as it does toward the southeast, there being 370 feet of red, gray and green shales and sandstones overlying the uppermost subdivision of his McKean county Chemung. He finds some red in his Chemung* as well as in the overlying Pocono. Fish beds occur in his Catskill as well as in the upper part of his Chemung. No information is given respecting distribution of molluscan remains, but on the eastern side of Potter, Chemung forms extend far up into the red beds, for, just over the border in Tioga county, Chemung fossils are found at more than 300′ above the first red beds.†

The condition in Tioga and Bradford counties, those next at the east, is sufficiently clear. Prof. White's incidental studies in those counties make it possible to utilize Mr. Sherwood's work, and at the same time to gain a good understanding of the work done by Prof. Hall and Mr. Vanuxem more than fifty years ago. The section near Blossburg, in Tioga county, gives a starting point.‡ It is

*Loc. cit. pp. 77-78.

†A Sherwood in Report of Progress in Bradford and Tioga counties. Harrisburg, 1878, p. 86.

‡Geology of Susquehanna and Wayne Counties. I. C. White, 1881, p. 72.

Pocono.	573′
Red shales, green and gray sandstones and concealed	830′
Fish conglomerate (*Holoptychius* bed)	2′
Red shale and sandstone	200′

The thickness of the rocks in the vicinity of Blossburg had been much underestimated by other observers. All the beds of the section below the Pocono have been regarded by authors as Catskill, but at ten miles further down the Tioga river, three miles below Mansfield, Chemung fossils have been found by Mr. Sherwood in a calcareous rock,* only 165 feet below the bed taken as the base of the Pocono in Prof. White's section, and therefore at more than 950 feet above the lowest red beds in that section. At a little way further east, Mr. Sherwood found great abundance of fish remains with shells and fragments of plants in the *Holoptychius* bed; a calcareous bed at 84 feet lower down contains abundance of well-known Chemung forms, while red beds continue in alternation with gray beds for 150 feet lower down in the column. In 1839, Prof. Hall connected his New York work with Pennsylvania at Tioga, eight miles further down the river, where he found the upper member of the Chemung passing under the Old Red sandstone, whose thickness he estimated at 400 feet. It is sufficiently clear that the red beds, including the fish bed, were regarded by him as belonging to the "Old Red Sandstone."

The McKean county section can be recognized without difficulty in Tioga county, despite the change in character of the rocks; for the middle division of Mr. Ashburner's Upper Chemung finds its equivalent in "Mansfield Reds" of Lesley, containing three ore beds near Mansfield, the second of which is the celebrated *Holoptychius* bed. The base of the Red and Gray group in McKean is at 900 feet below the Pocono, while in Tioga county the *Holoptychius* bed is at 830 feet. At the same time, the structure so well worked out by Prof. White in Susquehanna county, can be recognized with less difficulty than that of McKean. Eastward from the Tioga river, fossils become rarer in the upper part of the section; Mr. Sherwood states that no fossils occur in the Towanda basin of Bradford county until a bed is reached at 800 feet below the Pocono.†

Prof. White's work in Susquehanna and Wayne counties, was connected by him with that in Bradford, which lies between Tioga

*A. Sherwood, loc. cit. p. 79.

†Loc. cit. p. 28.

and Susquehanna. His section for those counties, condensed and re-arranged is*

CATSKILL.	
Cherry Ridge shales	110′
Honesdale sandstone	90′
CHEMUNG.	
Montrose red shales	180′
Paupack sandstone and shales, New Milford flags and shales	585′
Shales and sandstones	244′
"Mansfield Reds"	90′
(*Allegrippus*) Cascade Creek sandstone	25′
Shale and sandstone	120′

The lower portions of the column are not exposed in the counties. The Paupack sandstone, immediately underlying the Montrose shales, occupies the position of the *Lackawaxen* conglomerate, but it is not seen as a conglomerate except in eastern Wayne, on the border of Pike county. The Cascade Creek sandstone is the same with the Falls Creek sandstone of Bradford county, and with the *Allegrippus* conglomerate of Bedford and Huntingdon counties, the Lower Chemung conglomerate of Fulton county. A great part of the interval between these sandstones is represented further east by the Delaware flags. For the most part, this is the section observed along the Delaware river in Pike county of Pennsylvania, and in the adjacent portion of New York; and the Honesdale sandstone is the Montrose sandstone of Vanuxem.† Prof. White made diligent search for fossils, but no mollusks were found at any horizon more than 130 feet above the *Allegrippus*; but Chemung fossils are sufficiently abundant below that rock. *Archæopteris jacksoni* occurs in the Paupack or *Lackawaxen*.

III.

We have come once more to the Delaware river, the last point reached in the tracing of the easterly outcrop. Clearly the series is one: the middle portion, that between and including the two conglomerates, is evidently persistent all the way round, except perhaps in McKean and Potter counties of Pennsylvania, where, however, the difficulty lies most probably not in absence of the sub-group but in the absence of records.

*Geology of Susquehanna county and Wayne county. I. C. White. Harrisburg, 1881. pp. 56, 58, 59, 73. In accordance with Prof. White's suggestion (Geol. of Susquehanna R. Region, p. 52,) I have omitted the upper 375 feet of the section.

†Annual Report of N. Y. Survey for 1839, p. 381.

The serious question now arises, how shall this great column, with a maximum thickness of more than 7,000 feet, be divided and what value shall be assigned to the divisions? Before undertaking to answer the question, let us recall the signification of the terms Catskill and Chemung as originally employed.

Mather* in the annual reports as well as in his final report used the term "Catskill Mountain Series" to include all beds from the very highest rocks in the Catskill mountains down to the Corniferous, thus making it equivalent to "Formations VIII, IX, X, and XI of Prof. Rogers' Report on the Geology of Pennsylvania for 1838." "Catskill group" was used first by Vanuxem in his final report, published in 1842,† though he had previously fixed the lower limit, as may be seen by reference to the fourth report, where he takes the Montrose sandstone as representing the group. That rock rests directly on the Chemung group, whose upper limits are not so well defined in the fourth district of New York, though sufficiently so in the third. Its lower boundary appears to be distinct in both, so that the group consisted of the Chemung and Portage. But the Catskill group of authors is a variable quantity. By some, the whole mass in the Catskills proper has been taken as belonging to the group; by others, the first red bed is taken as the base of the group, while others still see the beginning in the first fish bed. No one of these limitations suffices, for each is purely local in character and cannot be applied over a great area.

Stratigraphically the two groups, as understood by Vanuxem, are separable without difficulty. The Catskill, including under that name, the Cherry Ridge shales of White and the Montrose sandstone of Vanuxem, is thoroughly persistent along the eastern outcrop from Greene county of New York to far beyond the James river in Virginia; its variations in thickness along this line are for the most part very similar to those of the upper and middle divisions of the underlying Chemung. Westward and northwestward, however, the variations of the Catskill are unlike those of the Chemung. In southern Pennsylvania, the Cherry Ridge shales disappear within forty miles, while the Montrose sandstone thins out more slowly and does not disappear until Fayette county is reached; there, however, the whole mass, 3,700

*Fourth Annual Report, p. 227. Geology of N. Y. Part I, p. 299.

†Geology of New York. Part III, p. 186; 4th Ann. Rep. p. 381.

feet thick in Fulton county, is wanting. In northern Pennsylvania, the decrease in thickness is abrupt for a few miles, but the final disappearance of rocks of the Catskill type is in Warren county, just as in New York it is in Allegany county east from the Genesee river.* In southwestern Pennsylvania the Catskill is wanting, because the rocks have thinned out; whether the disappearance in northwest Pennsylvania is due only to thinning or to interlocking with rocks of different color, cannot be determined in our present state of knowledge.

The upper sub-divisions of the Chemung, when followed westward, are found to vary much after the same manner throughout. The abrupt changes observed in the Catskill had no predecessors in the Chemung, except in southwestern Virginia, where the whole series, Chemung and Catskill, as well as most of the underlying Hamilton and much of the overlying Pocono have disappeared. The Chemung section thus grouped

VENANGO {
Shales
Sandstone
Shales and sandstone
Sandstone
Shales and flags

can be recognized not merely along the eastern outcrop from New York to far beyond New river in Virginia, but also in western Pennsylvania many miles beyond the western limit of the Catskill beds.

It is sufficiently clear that, at the close of the time embraced in the Chemung group, a physical change occurred, which, though not observable along the eastern outcrop, becomes very distinct within 100 miles westward or northwestward. During the whole of the Chemung period, the subsidence was less and less rapid toward the west and northwest, though doubtless keeping pace there as at the east with accumulation of deposits, which, in that direction, became less in quantity and finer in grain, as the rocks at the west and northwest were not such as to yield much coarse material. But at the close of the Chemung, the subsidence became still less rapid toward the west and northwest, so that the area in which Catskill was deposited became narrower toward the south.† It is altogether unnecessary to resort to the conception of elevation in western Pennsylvania or Virginia: indeed

*Geology of New York. Part IV. p. 279.

†Because of the southwestward trend of the Appalachian land area.

any such conception would be at variance with such evidence as from study of the stratigraphy. For the most part, the changes we have. That region was not above water at any time so as to make the Catskill deposit in a closed sea; no subaërial erosion took place there after the close of the Chemung, for the thickness of Montrose shales in the oil-wells and in northwest Pennsylvania, where they are Prof. White's Riceville shales, varies immaterially from their thickness in Somerset county, where they underlie the western edge of the Montrose or Honesdale sand-stone.

But while making use of these variations in rate of subsidence as affording a convenient method of separating the Catskill and Chemung groups, we must not forget that in by far the greater part of the area, the conditions exhibited in the Catskill are but a continuation, and as it were an intensification of those existing in the Venango portion of the Chemung. The appearance of red rock with green and greenish gray sandstone begins in Pennsylvania very little above the *Allegrippus* conglomerate, and continues in irregularly increasing quantity to the top of the column, while in New York, red rock makes its first appearance in the Portage.* The amount of red between the conglomerates varies greatly, being seldom more, though often less, than ten per cent. along the eastern outcrop, while at some places in western Pennsylvania it is much greater. The Montrose shales are largely red along the easterly outcrop, but they show not a little variation even there; while at the west, they are sometimes wholly red and at others without any red beds whatever. Greenish gray and brown or reddish brown sandstones occur in large proportion in the Catskill itself.

All observers agree that the passage of Chemung into Catskill is so gradual that, lithologically, no absolute line of separation can be drawn in a great part of the Appalachian basin. The bond between Catskill and upper Chemung is even more intimate, as far as structure goes, than is that between the upper Chemung and the lower Chemung or Portage. As far as physical characteristics are to be depended on, the whole series is one, and the terms *Catskill, Chemung, Portage* might well be taken as names of epochal divisions of the Chemung period.

The palæontological record confirms this conclusion drawn

*James Hall in 28th Annual Report of the Regents on the State Museum. 1876, p. 15.

in general conditions were insignificant from the beginning of the Portage to the close of the Chemung; at all events the changes in by far the greater part of the area under consideration, were not such as to interfere materially with the existence of the molluscan fauna known as Chemung, though as we have seen, there were circumscribed areas in which the conditions did prove very injurious to animal life.

The Chemung and Catskill are very distinct, palæontologically, along the eastern outcrop in southern Pennsylvania. The Catskill, almost wholly red shale and red or greenish-gray sandstones, appears to be non-fossiliferous: but the Chemung carries its fossils to practically the top of the Montrose shales. The condition is unquestionably the same in northern Virginia. Near the Tennessee border, the equivalent of the Montrose sandstone has Chemung fossils: at New River gap, Chemung fossils were not found in the upper half of the interval between the *Lackawaxen* and the Pocono: in McAfee's gap in Roanoke county, proof is shown that *Spirifera disjuncta* survived all changes to the end of the Catskill: while at eight or ten miles southeast in Catawba mountain, the whole succession of red greenish-gray sandstones seems to be absolutely non-fossiliferous; and this is the prevailing condition thence northward. It is evident, then, that from, say, twenty-five miles southwest of James river in Virginia to New York, the group called Catskill by Vanuxem is either non-fossiliferous or practically so. But the Chemung group contains its characteristic species above the *Lackawaxen* conglomerate in Virginia and along the eastern outcrop into Montour county of Pennsylvania; so also in southern Pennsylvania* westward to where it passes beneath the surface beyond the final disappearance of Catskill in Fayette and Westmoreland counties: while in northwestern Pennsylvania and along the northern line of the state, Chemung forms are present in the same upper horizon from the Ohio line eastward into Bradford county. In New York on the northwest border of the Catskills themselves, Chemung fossils occur abundantly above the Oneonta† sandstone which Vanuxem identified with the Montrose sandstone of Pennsylvania.

*In my report on the Geology of Bedford and Fulton counties, p. 81, I identified the conglomerate of the Laurel and Chestnut ridge gaps with the Lower (*Allegrippus*) conglomerate. The error was discovered too late for correction.

†James Hall in *Science* 1880, p. 290.

A remarkable feature of the Chemung is the non-fossiliferous area of southeastern New York and the adjacent portion of Pennsylvania, northward from Huntingdon county, of Pennsylvania, the upper limit of the Chemung fauna descends: in Columbia county the upper half of the Montrose red shales yields no fossils, while in Carbon county, no fossils were found until practically below the place of the *Allegrippus* conglomerate; and, even in these lowest beds, fossils are rare and usually not well preserved. No molluscan fossils were found by Prof. White in the Delaware river section until considerably below the place of the *Allegrippus*, whence downward "the whole series is sparingly fossiliferous."* Even remains of fishes are wanting aside from "the occasional appearance of what appear to be fish-bone fragments in calcareous breccias." A similar condition is observed as one comes eastward along the border of Pennsylvania and New York; Chemung fossils reach the top of the group at the western border and in McKean county; but in Tioga county the barren space at the top of the column is 165 feet; in Bradford, 800 feet, in Wayne, 1,170 and in Pike, 2,650 feet, in each case inclusive of the Catskill, which, however, does not exceed 300 feet even in Pike county.

The area in which the lifeless portion of the column reaches much below the horizon of the *Lackawaxen* conglomerate, embracing parts of Carbon, Monroe, Pike and Wayne counties of Pennsylvania, and of Sullivan, Delaware, and Greene counties of New York, contains rather more than 4,000 square miles, while the whole area under consideration is more than 30,000 square miles. To explain the absence of life is not easy; it cannot be due merely to an agent which caused the redness or greenness of the beds, for, in Huntingdon and Fulton counties of Pennsylvania, the Montrose shales have many fossiliferous beds though having also many green and red beds. Besides, the Delaware section shows a great thickness of beds of other colors, which are equally without animal remains. It cannot be due to chemical conditions existing in a closed sea, for the successive subdivisions of both Catskill and Chemung can be traced directly into the lifeless area equally from the open sea at the west and along the Appalachian shore from the south, thus showing that no closed sea existed in that area. Even plant remains are rare, being

*Geology of Susquehanna River region. pp. 103 and 105.

found at but few localities and as a rule the specimens are imperfect, good specimens occurring at only a very few places. There is little room to suppose from the condition in which the plants are found that alternations of salt, fresh and brackish water conditions caused the absence of animal life. It is certain that from the beginning of Oriskany to the end of Catskill, even during the formation of the Corniferous coral reefs, the Appalachian gulf was shallow everywhere. During the later time, when subsidence did little more than to keep pace with the inflow of sediment, the area nearest to the region of great drainage, whence large streams with rapid flow poured their material into the shallow basin, would show muddy bottoms and muddy, more or less brackish water, which would be unfavorable to animal life of Chemung types. As the Appalachian land became narrower southward, the untoward conditions are less marked in that direction. Within the portion of the area lying within southeastern New York and the immediately adjacent portion of Pennsylvania, these conditions may have been begun as early as the Hamilton, as suggested by Prof. Hall.*

The molluscan fauna of the Chemung and Catskill is unquestionably marine. Even the mollusks found in New York above the Oneonta sandstone belong to the ordinary forms. Of course it is possible, even probable, that at the extreme northeast there were small areas at the mouths of large rivers, where fresh water prevailed and fresh water mollusks lived, but positive evidence of this is wanting. The *Amphigenia* found in the Oneonta sandstone of New York may be a freshwater form, but it occurs in the Montrose sandstone in southern Pennsylvania so far away from the old shore line that freshwater conditions seem, certainly, improbable.

The stratigraphical relations of the fishes have been generally misunderstood. The fishes exist for the most part not in the Catskill but midway in the Chemung, the celebrated *Holoptychius* Bed, is the second ore bed of the "Mansfield Reds," and belongs at but a little way above the *Allegrippus* conglomerate, the Falls Creek sandstone of Bradford county. It has yielded large numbers of fish remains at several localities and it contains marine fossils.† The *Cocosteus* bed of Warren county is taken by Prof.

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The conclusions to which I am led are

First. That the series from the beginning of the Portage to the end of the Catskill, forms but one period, the Chemung, which should be divided into three epochs, the Portage, the Chemung and the Catskill.

Secondly. That the deposits of the Catskill epoch were not made in a closed sea or in freshwater lakes.

Thirdly. That the disappearance of animal life over so great part of the area toward the close of the period, was due to gradual extension of conditions existing in southeastern New York as early, perhaps, as the Hamilton period.

Fourthly. That the Chemung period should be retained in the Devonian.

PRINCIPLES AND METHODS OF GEOLOGIC CORRELATION BY MEANS OF FOSSIL PLANTS*

By LESTER F. WARD, Washington, D. C.

In all work on geologic correlation, whether by means of fossils or of stratigraphy, the modern doctrine of homotaxis should, I think, be carefully kept in mind, as it is now well recognized that identical forms do not necessarily indicate indentity of age.

In the eighth chapter of his well known work on Paleontology, M. Pictet lays down the following general principle: "Contemporaneous deposits, or those formed at the same epoch, contain identical fossils. Conversely: deposits which contain identical fossils are contemporaneous."†

Schimper, in his Vegetable Paleontology accepts this statement and adapts it to plants in the following form: "Contemporaneous deposits, or those formed at the same epoch, contain floras, if not completely identical, at least homologous, and consequently deposits that contain identical or homologous floras are contemporaneous."‡

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the upper; and when the notion of age was once introduced as the equivalent of succession, it was no wonder that correspondence in succession came to be looked upon as correspondence in age, or contemporaneity; and, indeed, so long as relative age only is spoken of, correspondence in succession *is* correspondence in age; it is relative contemporaneity.

But it would have been much better for geology if so loose and ambiguous a word as "contemporaneous" had been excluded from her terminology, and if, in its stead, some term expressing similarity of serial relation, and excluding the notion of time altogether, had been employed to denote correspondence in position in two or more series of strata.

In anatomy, where such correspondence of position has constantly to be spoken of, it is denoted by the word "homology" and its derivatives; and for geology (which after all is only the anatomy and physiology of the earth) it might be well to invent some single word, such as, "homotaxis" (similarity of order), in order to express an essentially similar idea."

The term "homotaxis", thus introduced into geologic terminology, has been widely accepted, and is now in constant use, even by those who have not taken the trouble to inquire how it originated. The geologist considers the stratigraphical and lithological relations and the paleontologist the related organic forms. As regards the latter class of workers, they are, I believe, agreed that two deposits should be considered homotactic* when their floras or faunas show a sufficiently large number of identical or closely allied species, or contain to a considerable extent the same types of life.

I fully share with Dr. Newberry the view that fossil plants may be made of great value in the correlation of geologic strata, and also that when properly understood there will remain no conflict between animal and vegetable fossils. The difficulty has all along been that the science of paleobotany is in an unsettled and unorganized state, and that correct principles have been wanting for the application of paleobotanical data. It is not claimed that the science has advanced to the point where its usefulness is at its highest stage; it is still as it were in its infancy. Nevertheless a sufficient body of facts now exist to make it a useful aid to geology.

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*This seems the proper adjective form, and not "homotaxial" as some authors write it.

found at but few localities; and as a rule the specimens are imperfect, good specimens occurring at only a very few places. There is little room to suppose from the condition in which the plants are found that alternations of land, fresh and brackish water conditions caused the absence of animal life. It is certain that from the beginning of Oriskany to the end of Catskill, even during the formation of the Corniferous coral reefs, the Appalachian gulf was shallow everywhere. During the later time, when subsidence did little more than to keep pace with the inflow of sediment, the area nearest to the region of great drainage, whence large streams with rapid flow poured their material into the shallow basin, would show muddy bottoms and muddy, more or less brackish water, which would be unfavorable to animal life of Chemung types. As the Appalachian land became narrower southward, the untoward conditions are less marked in that direction. Within the portion of the area lying within southeastern New York and the immediately adjacent portion of Pennsylvania, these conditions may have been begun as early as the Hamilton, as suggested by Prof. Hall.*

The molluscan fauna of the Chemung and Catskill is unquestionably marine. Even the mollusks found in New York above the Oneonta sandstone belong to the ordinary forms. Of course it is possible, even probable, that at the extreme northeast there were small areas at the mouths of large rivers, where fresh water prevailed and fresh water mollusks lived; but positive evidence of this is wanting. The *Amphigenia* found in the Oneonta sandstone of New York may be a freshwater form, but it occurs in the Montrose sandstone in southern Pennsylvania so far away from the old shore line that freshwater conditions seem, certainly, improbable.

The stratigraphical relations of the fishes have been generally misunderstood. The fishes exist for the most part not in the Catskill but midway in the Chemung; the celebrated *Holoptychius* Bed, is the second ore bed of the "Mansfield Reds," and belongs at but a little way above the *Allegrippus* conglomerate, the Falls Creek sandstone of Bradford county. It has yielded large numbers of fish remains at several localities and it contains marine fossils.† The *Coccosteus* bed of Warren county is taken by Prof.

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‡"Les terrains contemporains ou formés à la même epoque renferment des flores, sinon complètement identiques, du moins homologues, et par conséquent: Les terrains qui renferment des flores identiques ou homologues sont contemporains." Traité de Paléontologie Végétale, etc.; par W. Ph. Schimper. Vol. I, Paris, 1869, p. 100.

the upper; and when the notion of age was once introduced as the equivalent of succession, it was no wonder that correspondence in succession came to be looked upon as correspondence in age, or contemporaneity; and, indeed, so long as relative age only is spoken of, correspondence in succession *is* correspondence in age; it is relative contemporaneity.

But it would have been much better for geology if so loose and ambiguous a word as "contemporaneous" had been excluded from her terminology, and if, in its stead, some term expressing similarity of serial relation, and excluding the notion of time altogether, had been employed to denote correspondence in position in two or more series of strata.

In anatomy, where such correspondence of position has constantly to be spoken of, it is denoted by the word "homology" and its derivatives; and for geology (which after all is only the anatomy and physiology of the earth) it might be well to invent some single word, such as, "homotaxis" (similarity of order), in order to express an essentially similar idea."

The term "homotaxis", thus introduced into geologic terminology, has been widely accepted, and is now in constant use, even by those who have not taken the trouble to inquire how it originated. The geologist considers the stratigraphical and lithological relations and the paleontologist the related organic forms. As regards the latter class of workers, they are, I believe, agreed that two deposits should be considered homotactic* when their floras or faunas show a sufficiently large number of identical or closely allied species, or contain to a considerable extent the same types of life.

I fully share with Dr. Newberry the view that fossil plants may be made of great value in the correlation of geologic strata, and also that when properly understood there will remain no conflict between animal and vegetable fossils. The difficulty has all along been that the science of paleobotany is in an unsettled and unorganized state, and that correct principles have been wanting for the application of paleobotanical data. It is not claimed that the science has advanced to the point where its usefulness is at its highest stage; it is still as it were in its infancy. Nevertheless a sufficient body of facts now exist to make it a useful aid to geology.

*This seems the proper adjective form, and not "homotaxial" as some authors write it.

I propose, in this paper, to first set forth a few principles which, as it seems to me, should govern the study of paleobotany as an aid to geologic correlation, and then to explain the methods which I have adopted for their application.

I. Principles.

Bearing in mind the law of homotaxis, and not forgetting that similar floras may have flourished in different parts of the world at different times, it nevertheless still remains true that the occurrence of similar floras in different parts of the world, has a strong bearing upon the question of the age of the strata in which these floras occur. That is to say, although these floras may have flourished at different times, the difference between the epochs at which they grew cannot be very great, and while an exact identity of age cannot be predicated, still it is safe to say that deposits containing similar floras must have been laid down at no great distance apart chronologically speaking.

The great types of vegetation are characteristic of the great epochs in geology, and it is impossible for types of one epoch to occur in another. For example: It frequently happens in a region which is much broken up that the stratigraphical geologist is greatly puzzled to determine the relative position of certain rocks. The time has gone by when geologists rely implicitly upon the appearance of the rock in determining age, and rocks of Carboniferous age may have so close a resemblance to those of Tertiary age that it is impossible to distinguish them lithologically. In such cases a single characteristic fossil found in place is sufficient to settle the question. The fossil may be a mere fragment not specifically determinable, but if its reference to a great type of vegetation is certain this is as conclusive as if it were known to what species it belonged. For example, a dicotyledonous leaf from a stratum supposed to be Carboniferous, enables the paleobotanist to say with absolute certainty that such a reference is impossible. On the other hand a single scar of Lepidodendron or Sigillaria from a deposit supposed to be Tertiary or Mesozoic is equally conclusive. It may be said that such cases are not common, but I have had in my limited experience a number of instances of precisely this nature where thoroughly competent geologists were much perplexed, and were set right by such a single fact.

The celebrated case of the beds of Chardonet, department of Hautes-Alpes, studied by Elie de Beaumont in 1828, and positively referred to the Mesozoic, but in which fossil plants of the genera Calamites, Sigillaria, and Lepidodendron were identified by Brongniart, is one of the best illustrations of this principle. And although, so young was the science of paleobotany at that time, that Brongniart himself was inclined to admit that these genera might occur in the Mesozoic, still, long before his death this was known to be impossible, and no paleobotanist would now hesitate in a similar case to tell the geologist that he had certainly made a mistake in his stratigraphy.

But in the determination of nearly related strata this is not possible, and limited material or single fragmentary specimens are not adequate. For such cases in order to be certain it is necessary to have a body of facts; in other words a fair series of good specimens of fossil plants is required before the paleobotanist ought to attempt to express his opinion with regard to the exact age of the deposit in which they are found. Most of the serious mistakes which have been made, and which have gone far to bring the science of paleobotany into disrepute, have resulted from neglecting this principle. Purely stratigraphical geologists have no conception of these laws, and a paleobotanist has to deal with them very much as he would deal with the notions of unscientific persons. They are constantly bringing him mere fragments and only isolated specimens, not perhaps specifically determinable, and they expect of him that from such material he will be able to tell them the exact age to which it belongs. This is simply impossible, and the paleobotanist who will base definite conclusions upon such material is certain to err.

On the other hand, where such a sufficient body of facts exists paleobotany becomes as conclusive for more nearly related formations as for more widely separated ones. As an illustration of this, take the clays of Gay Head, Massachusetts. There is no spot more tempting to the stratigraphical geologist in this country than Gay Head. Beautifully stratified clays of varied hues marking the dip and always freshly worn, form a precipitous cliff visible as a gayly colored object from great distances at sea: and about the first work that geologists did in America was to attack the problem of the age of this cliff. The records of this work date back one hundred years, and the names of the most eminent

geologists of the United States have been associated with it. As a final outcome of all this stratigraphic work in such an inviting field, the conclusion has been at last announced by Professor Shaler, within the last two years, that these clays are of Tertiary age (Miocene or Pliocene). Almost simultaneously with this authoritative announcement, a young paleobotanist, Mr. David White, of the United States Geological Survey, visited this spot and spent a summer in obtaining a collection of fossil plants. A few fragments had hitherto been found, and one or two of them had been figured in the works of Dr. Hitchcock. But such limited material was of no value. The specimens were obscure, and nothing could be concluded from them. Mr. White made a large collection of fine specimens of fossil plants. They were shipped to Washington, and he has determined them. They are found to be nothing more nor less than types of the Amboy clays of New Jersey, and therefore represent the Cretaceous.

This discovery has a wider significance than the mere proof that the plant bearing strata at least, of Gay Head are Cretaceous; it also proves that the Amboy clays of New Jersey, after passing eastward and reappearing on Long Island stretch still farther in that direction, and probably underlie most of the glacial deposits of Block Island, the Elizabeth Islands, Martha's Vineyard, and Nantucket. Thus has paleobotany, legitimately employed, set at rest a question which stratigraphical geology could probably never have answered. Many other illustrations of this principle might be given, but this one will suffice for all.

There is one other principle to be considered, the ignoring of which has long been a stumbling block to geology, and to paleobotany as well. It is indeed impossible to overestimate the importance of the correct systematic determination of fossil plants. The doubts which exist with regard to the true nature of many of the vegetable objects found in the earth's strata, have led to great skepticism on the part of many with regard to the value of paleobotany as a science. Botanists in particular, who have had something to do with paleobotany, are as a rule much disappointed. Accustomed as they are to having before them the entire structure of the plant, all its parts and organs, not only of vegetation, but of reproduction, they have little patience with such fragmentary material as constitutes the bulk of most collections of fossil

plants. And geologists are apt to reflect their opinions and to join with them in condemning paleobotany.

There are two answers to all these objections. There is an answer to the botanist, and a separate answer to the geologist. The answer to the botanist is that, considering the conditions under which we find these specimens, there really does exist a large amount of information of a somewhat exact and reliable kind with regard to the past history of vegetation. Aside from the fact that at some points on the earth's surface fossil floras are known to exist which almost equal in number of species the existing floras of the same localities, there is the further answer that paleobotany teaches us to study more carefully the fragmentary remains that we find; it sharpens our powers of observation upon the facts which are in our possession and has added not a little to our knowledge of botany proper. For example, it is the habit of botanists to figure leaves so carelessly that the paleobotanist is unable to tell the genera to which they belong. This is chiefly due to the fact that they ignore, as a rule, the exact nervation of leaves, and are content to figure them almost from the standpoint of the artist, merely for the sake of the effect. Paleobotany has taught the botanists that the nervation of leaves is important, and that wherever possible it should be carefully figured. We are indebted to fossil plants for the discovery that nervation in leaves is of generic rank, whereas form, upon which the botanist chiefly relies, is usually only of specific rank. Leaves, therefore, which show nervation are not useless in determining species, but are valuable, and by them alone genera may in many cases be made out with certainty.

Still answering the botanist, it may be further urged with justice, that in the case of nearly all problematical forms as ancient as the Cretaceous, it must not be supposed that the genera can be determined by comparison with genera of living plants. It is to be expected that the genera with which we are dealing in these ancient strata, are extinct, and all that we are called upon to look carefully for is evidence of their being related to or the ancestors of our modern plants.

The answer to the geologist is still more conclusive: in fact he has no right to raise any objection whatever. It really makes no difference to him whether the form that the paleobotanist has named, is correctly named or not; this question is one of purely biological importance, it is one of no geological importance. But

that which is of geological importance, is that the form in question be distinctly recognized, that it be carefully portrayed, and that what has been found be characterized in accurate descriptive language and represented by clear and careful delineation. There must be no doubt when the same form is seen again at a different locality, as to whether it is really the same form. This is a vital point with the geologist. If the form, no matter what it may really be, is something clear and distinct, which can be recognized when seen anywhere, and if it is characteristic of a given horizon or locality, it becomes to that extent of value in fixing the relative age of any other deposit in which it may be found. If only found in two localities or at two points on the earth's surface the deduction, though not absolute, is legitimate that unless there is evidence to the contrary the two localities are of somewhat similar geologic age. But if the object be very abundant, and characteristic of some well known group or horizon, then it is that it becomes of great importance as a characteristic fossil, independently of how much may be known of its true botanical nature.

II. Methods.

I propose next to indicate the general method which I have adopted in the application of these principles to geologic correlation by the aid of fossil plants.

In a broad sense this, of course, consists in the comparison of similar floras, and the conclusion from them of similarity of age; but there are many limiting circumstances to be taken into the account. If the localities at which similar floras occur are not widely separated geographically, the conclusion of similarity of age is more or less reliable. For example, when we find that the flora of the Richmond coalfield is very similar to that of the North Carolina coalfield, the inference that these two coalfields are of similar age is wholly legitimate. And even when we find the same species, to a considerable extent, in the Triassic of New Jersey and in that of Connecticut and Massachusetts as occurring in Virginia and North Carolina, the inference cannot be very wide of the mark that the strata containing these plants were deposited at about the same time from Massachusetts to North Carolina.

In proportion as these similar floras are separated geographically the inference of the similarity of age and deposition grows weaker, but it will remain strong as long as the two localities are on the same continent, or as evidence exists that an unbroken sea

once stretched all the way from the one to the other, or that similar lakes or estuaries existed in both parts of the continent at the same time. Such is the case when we compare the Triassic of the eastern states with that of New Mexico, Arizona, and Central America, and although the floras of these widely separated parts of the American continent are considerably different, still it has been argued by eminent geologists that the occurrence of a large number of identical species, and a similar facies in the type of plants indicate the former existence of a great Triassic sea of nearly uniform age, from New Mexico to Honduras; and not widely different in age from the corresponding one which extended on the eastern side of the continent from Massachusetts to North Carolina. The same principle could be applied to many other epochs in geologic history.

What then is the specific method adopted in comparing floras? It may be briefly defined as the preparation of tables of distribution and their discussion. As already remarked, the more complete the flora of any group to be considered is the more accurate will be the comparison. Therefore the first work to be done is to make a complete list of all the fossil plants that have been found in the given group. This list of species may be primarily regarded as wholly unknown geologically.

If there are several distinct localities, areas, or basins which are suspected to be of similar age, the species or forms that occur in each of these must first be enumerated separately and comparisons made to ascertain to what extent they are the same or similar for the different florules. This is what, in my Triassic work I have called the *American distribution*. The number of forms common to any two such areas will indicate the botanical resemblance between such two florules. Thus in the Triassic flora of the United States as known at the present time, the following table shows the number of species common to two or more of the basins:

Areas	Areas			
	New Jersey and Pennsylvania.	Virginia.	North Carolina	New Mexico and Arizona.
Connecticut Valley	5	5	6	1
New Jersey and Pennsylvania...		7	10	2
Virginia..........			20	2
North Carolina....				2

But as the number of species occurring in the different basins

is very different these figures might lead to an erroneous impression. What it is desired to learn is the relative preponderance in any florule of species common to other florules. This can only be shown by a table of percentages. For the Triassic basins of the United States I present this information in the following form:

Basins or Areas.	Occurring in	Confined to—	Common to and some other basin	Per cent. in other basins.
Connecticut Valley	23	13	9	39
New Jersey and Pennsylvania.	18	5	13	72
Virginia	56	34	22	39
North Carolina....	52	25	27	52
New Mexico and Arizona......	13	11	2	15

Considering the well known fact that in almost any new locality for fossil plants, the majority of the forms found will be new to science, the percentages of common species here shown, with the exception of the western basin, are large and may fairly be taken to prove actual or approximate contemporaneity of deposition.

The next step is to ascertain how many of the species have been found at other localities and horizons. This is what I have denominated their *foreign distribution*. To show this a table is prepared with columns for such different foreign localities, arranged in ascending geological order, the lines of which are occupied by the species found in the locality to be compared. The species that have been already described from other localities and horizons are then indicated in the proper column by some characteristic mark. The range or geologic history of each species is thus recorded upon the same line on which the species is written.

Such a detailed table of distribution of the species of any given group, is exceedingly simple and elementary; and in so far as it goes requires no explanation. But there are other considerations to be taken into the account. In all the lower forms, consisting chiefly of cryptogams, cycads, and conifers, two facts are to be considered: In the first place it is to be remembered that our knowledge of the nature of these ancient forms is not sufficient for us to predicate with certainty their generic relationships. They are usually extinct forms and are given names accordingly as extinct genera. In the second place, as all paleontologists now know, the ancient forms of life on the globe were less definite, or

as it is expressed in modern scientific language, less completely differentiated than they are at the present day. The consequence is that we are all the time changing from one genus to another, and from one family to another as the evidence accumulates.

Now there is no doubt that the later forms of life, both animal and vegetable, have developed from earlier forms, and these transition stages in the paleontologic record enforce this truth far more strongly than any facts in the living faunas and floras of the globe. Assuming then that the later floras are derived from the earlier ones, it is of the utmost importance, not only to the botanist, but also to the geologist, to trace these ancestral relationships of plants, and this can be done with considerable success. Therefore in the preparation of a table of distribution we must not confine our attention exclusively to the species which are found in the group to be compared. In fact so variable are these ancient forms that it would be impossible to do this. It would be very misleading to be guided exclusively by the names given to the species. The forms differ in different localities by such slight divergences that the personal equation of the describer would vitiate such a calculation. Some would join similar forms from different localities, others would separate them as distinct species, and the history of the nomenclature of paleobotany is merely a record of these apparently conflicting determinations, but which in reality after all, merely show that the forms are more or less closely related, although they can never agree in all respects.

This, therefore, is the difficult part of the preparation of a table of distribution, viz., to select not only the species which are universally regarded as identical in two or more horizons, but also such as are believed to be related to those of the group under consideration. There is danger on the one hand of leaving out important related species, and on the other hand of introducing, as related species, those which really have no affinity. Without dwelling upon the details of this difficult part of the task, it must be assumed that the paleobotanist, if skilled in his craft, possesses that judgment which will enable him to distinguish the truly related species from those which are only apparently so. To the species then which all admit to occur at more than one horizon or in more than one place, and which we will, for the sake of brevity, denominate *identical* species, must now be added to those which are related to species of the group, and which may be called *related*

or *allied* species. But this introduces a new element into the table since it is manifestly impossible to indicate these relationships by the same means which were used to indicate identity. It is necessary to use a separate line for each of these related species: also to use an additional column at the left hand of the margin in which to write their names. It is then possible to use the same sign for the related species as was used for identical species, and to carry out its geological distribution in the columns as above described.

Such a table is useful when one wishes to follow out any one particular species, and to trace its distribution to other localities and horizons. But it does not give a comprehensive view of the relationships of the flora in general: the data which it contains require to be condensed into more convenient form.

The first step in such condensation should probably be the arrangement of all the species in the ascending geological order, of the formations in which they also occur. It is instructive in such a table to show the indentical and the related species for each formation separately; that is to say, all the species together which are found at the lowest, next lowest, third lowest formation, etc., of the entire range of the group. In this way those horizons at which the largest number of species occur are clearly brought into view, not only by the number of species which occur in them, but also by the relative number of those which are identical to those which are merely allied.

This condensation may be still further generalized by the reduction of the list of species to the numerical form; that is, by a statement of the number occurring at each horizon without enumerating the species at length. Just as in the table last mentioned the same species will often be several times repeated, so in the table now under consideration,* the numbers in the columns include such over-lappings. Hitherto we have considered the subject only from the geological standpoint, but it is of interest to geology as well as to botany that some classification be made of the principal types of vegetation embraced in any flora. As the table last described is very short it is possible to introduce some such classification in it. In discussion the Triassic flora, which has

*This table appears in the Bulletin of the Geological Society of America, Vol. iii, p. 29. The larger tables used to illustrate this paper will be published in my essay on correlation, in preparation.

been the basis of my remarks upon the method pursued. I have here shown the number in each horizon respectively, of ferns, equiseta, rhizocarps, cycads, and conifers, these being the only types represented in the foreign distribution of that flora.

The method of reasoning with regard to the age of the formation from data of this kind, is important to be considered. The usual way is to prepare only some such extended table as the first one described, often without taking account of related species, and then to proceed to discuss each species and its bearings upon the age of the group. The data thus considered are only absolute, not relative, and conclusions drawn from them are apt to be very misleading. I have frequently pointed out that the great mistakes of Heer and Lesquereux in placing the American plant-bearing strata too high in the geological scale was due to this fallacy. These geologists compared the Dakota group flora, the Laramie group flora, and all the higher floras of the United States with those of the Miocene of Europe and of the Tertiary of the polar regions. They laid great stress on the fact that species were found in these formations which could not be distinguished from American species, or which could scarcely be so distinguished. Such an argument is of little value in view of the immense magnitude of the Tertiary floras considered. The Tertiary flora of Europe embraces elements of antecedent floras, and it is so well preserved that the number of these pre-Tertiary forms, holding over into the Tertiary, is far greater than the number of pre-Tertiary forms that have thus far been found in lower formations, which have yielded comparatively few plants A comparison, therefore, of the American Laramie group, for example, with the European Tertiary alone without considering the European Cretaceous flora, and without noting this continuance of Cretaceous types into Tertiary time, proved to be extremely misleading, and resulted in the general impression, which still prevails in Europe, that our Laramie group is of Tertiary age. Perceiving this fallacy I was the first, and so far as I know, am the only one, to attempt an enumeration of the Cretaceous species of fossil plants with a view to their comparison with those of the Laramie group of the United States.*

The system which I have just described obviates this fallacy.

*Synopsis of the Flora of the Laramie Group. Sixth Ann. Rept. of the U. S. Geol. Surv., pp. 443-514.

In fact it makes a comparison of the forms determined with those of all the formations in which any of its species occur. In reasoning with regard to it, therefore, one is constantly checked in considering any particular horizon, by the facts relating to the horizons both above and below. For example, in treating the Triassic flora in the numerical table last described, if one's attention were confined either to the Oolite or to the Lias, one might conclude that either of these formations was near to the one to be determined. But dropping the eye down the column to the Rhetic it is observed that a considerably larger percentage of the same species, both identical and related, occur in this. So great was this similarity that Professor Fontaine decided that this must represent the nearest approach in geologic age to the Richmond coalfield. But the subsequent researches of Stur, with which Professor Fontaine was, of course, unacquainted, in the Keuper formation of Lunz, in Austria, and in the Keuper floras of Europe of nearly the same age, especially those of Raibl in Carinthia, and of Neue Welt in Switzerland, have shown that the Keuper flora of Europe, although much less abundant, contains a larger number of American Triassic forms than does the Rhetic flora of Franconia, South Sweden, Brunswick, etc. So that although only a very few American forms occur at any horizon lower than these, nevertheless we seem compelled to conclude that this Upper Keuper horizon of Lunz, Austria, comes nearer to that of the American plant-bearing Triassic deposits than does any other in the world.

Now the question may arise whether all this really proves anything. Where two floras as old as the Trias and as widely separated as Austria and Virginia are found to agree so remarkably in the forms they contain, is it legitimate to conclude that the age of the one was the same as that of the other? Certainly not. And yet, if facts like this do not prove that there existed an epoch on both sides of the Atlantic, which to all intents and purposes may be regarded as simultaneous, then all paleontologic data are without value. The fact to be borne in mind is that the correlation established by such data is homotactic and not necessarily chronologic. Reasons may exist why the same types may have come upon the stage at a later or earlier period at one of these localities than at the other. But of the nature of these retardations or advancements we are without scientific explana-

tion. What we possess is the general fact that a similar flora once existed in two parts of the world very widely separated, and until some other facts are discovered which complicate and vitiate such a conclusion, it is both safe and useful for the geologist to regard the two deposits as belonging to the same geologic age. There are certain limitations within which this must be true, and when these limitations are recognized the paleontologist may as safely draw his conclusions as he could before the law of homotaxis had been formulated.

AGE OF THE LIMESTONE STRATA OF DEEP CREEK, UTAH, AND THE OCCURRENCE OF GOLD IN THE CRYSTALLINE PORTIONS OF THE FORMATION.

By WILLIAM P. BLAKE, Shullsburg, Wis.

The Deep Creek region, so called, lies along the western border of Utah territory and nearly southwest of the Great Salt lake. It borders upon the state of Nevada, and has lately been brought into prominence by reason of the development of deposits of argentiferous lead ores and of auriferous copper ores. The prevailing formations are granite and limestone. The limestone is largely developed, and forms ranges of hills and mountains of considerable extent, trending generally in a northerly and southerly direction, parallel with the ranges of Tintic and of the southern end of Salt lake. The principal range, known as the Ibapah, forms the eastern side of Deep Creek valley. Ibapah mountain, the highest peak of the range, is said to be the highest mountain in Utah: higher even than any of the grand mountain masses of the Wahsatch, not excepting Mt. Nebo. Ibapah is flanked on the north by massive strata of limestone, which in some places, notably at Gold Hill, are much uplifted and metamorphosed apparently by intrusions of granitic and porphyritic dykes, the alteration consisting in loss of color (the ordinary grayish-blue color being changed to white), a coarse crystallization, and the formation of a variety of silicates, such as garnet, tremolite and tourmaline, especially near the planes of

contact with the dykes. There is also more or less mineralization in places, either in the form of vein-like beds, or in isolated patches and bunches at a considerable distance from any crystalline rock—but not outside of the crystalline and whitened portions of the limestone. This last observation applies particularly to some of the copper ores found in the midst of the limestone existing primarily as the variegated sulphuret—erubescite. These ore nodules have decomposed and have formed green carbonate of copper, which stains the rock for a considerable distance around and beyond the original nodule, or bunch, of sulphide. In such places free gold of high grade may be found by crushing and washing the rock. This noble metal occurs also independently of any cupriferous mineralization in the midst of masses of colorless tremolite, in coarse grains and strings in very much the same form in which it is found in other regions ramifying through quartz. This is an unusual and unique association of gold. It has been found, but rarely, in close association with greenish black hornblende in veins composed partly of quartz and partly of dolomite, but never before, to my knowledge, in white tremolite. This tremolite carries, also, some small disseminated crystals of iron pyrites.

The limestone in which the gold occurs appears to be the Lower Carboniferous, or Mountain limestone, as shown by an abundance of fossils, chiefly of the genus *Productus*, found a short distance east of Gold Hill.

From the fact that coarse gold in placer deposits has been found at Osceola and its vicinity, nearly south of the Ibapah mountain, it would appear that there is a gold region extending north and south near the Nevada and Utah line, and that the placers were formed during the period of great precipitation or rainfall which preceded the present era of gradual dessication At the place where gold is now taken from heavy deposits of boulders and gravel, the flow of water is wholly inadequate to the formation of such deposits. Probably the deposits were formed during the great glacial epoch of which there are such magnificent records in the Sierra Nevada, and the Wahsatch as well as in the ancient beaches of lake Bonneville. A good supply of water, even for ordinary purposes, is now one of the greatest needs of the Deep Creek region.

EDITORIAL COMMENT.

ARCHEAN ERUPTIVE ROCKS OF FINNLAND.

Studien ueber archaische Eruptivgesteine aus dem sud westlichen Finnland. von J. J. SEDERHOLM. (*Mineralog. und petrogr. Mitth. XII, 1891.*

This paper is an interesting and clear statement of the results of detailed geological and petrographical studies, in a field whose general features have already been described and mapped by Dr. Sederholm, in the Swedish language.

The Archæan age of the rocks investigated is determined by the geological condition which obtains generally throughout very extensive regions in Finnland, viz: that the Cambrian and Silurian rocks are found constantly in a perfectly horizontal and undisturbed attitude, while the underlying pre-Cambrian have been much folded and altered. In the field described by Dr. Sederholm the immediate superposition of the Cambrian is not observed, but the rocks he treats of are identical petrographically and in the conditions of their occurrence, disturbance and alteration with rocks the pre-Cambrian age of which is demonstrated; so that he infers them to have been in existence prior to the great epochs of disturbance and erosion, which antedated the Cambrian in this part of Europe, and hence Archæan.

Among the different formations which the author recognizes and describes may be mentioned first a series of *phyllites*, *mica schists* and *hornblende schists*, all of which appear to be altered sedimentary rocks. These altered sedimentary formations are surrounded by granite rocks, which penetrate them in innumerable dykes and veins, both transverse and parallel to the planes of schistosity. For a portion of these granites the term "*Adergneiss*" is used as descriptive of its intimate interveining with the schists. Occurring in extensive masses there are two chief varieties of granites of quite different age, viz: (1). A *gray granite*, rich in plagioclase and having generally hornblende as a constituent. This possesses often such a well marked parallel structure that it is commonly alluded to as gneiss. This parallel structure is held to be a pressure effect. In the midst of this granite there occur masses of basic rocks sometimes several kilometers in extent, but generally much smaller. These pass by gradations into the enveloping granite, and are held to be more basic separations or secre-

tions from the same magma. These basic masses are now in part much altered, but they may be classed with the *diorites*, *gabbros* and *peridotites*. This gray granite formation is shewn to cover a much more extensive area than the schists, and it is held to constitute a geological unit and to be *younger* than the schists with which it is in contact.

(2.) A *reddish granite with garnets* The feldspar is chiefly microcline, which is often in part intergrown with quartz in the manner of pegmatite. The mica is chiefly and sometimes exclusively muscovite. The coarser varieties of this muscovite granite pass into pegmatite. This red granite is younger than the gray granite. The red granite also shews very commonly a parallel structure, but this cannot be ascribed so definitely to pressure effects as in the case of the older granite, but it is rather to be referred to some primary condition. Associated with these formations there is in the middle portion of the region examined a long belt, varying in width from two to seven kilometers, composed of fine grained rocks rich in hornblende, of which the most typical variety possesses a well marked porphyritic structure, and is known as *uralitporphyrite*. There are some minor varieties referred to, as *melaphyre*, *plagioclase porphyrite*, and *amygdaloid*, which are genetically allied to the typical uralitporphyrite. Outside of this belt there are other occurrences, but of limited extent. Notwithstanding the great alteration which these rocks have undergone, it is possible to recognize their original characters. They constitute a series which accords perfectly with some of the younger volcanic rocks. The occurrence of vesicles, of rocks which were originally glassy, and of tuffs and other volcanic ejectamenta is proof of the fact that for the development of these great eruptive formations there must have been a true volcanic activity. There was first an eruption of a comparatively acid magma, which solidified as a highly feldspathic andesite. There was at the same time, however, also a basic magma produced, from which arose melaphyre and plagioclase porphyrite. The cause of the metamorphism of these rocks is sought for in the strong mountain folding which occurred in pre-Cambrian time. By this agency the eruptive formations buried deep in the crust were folded together and altered apparently under the influence of solution. The relative age of these various geological formations is determined by the following facts: The *uralite porphyrite*

formation is found in contact with the gray granite and the dioritic rocks genetically associated with it; it is also found in contact with the schists and with the red granite. From a critical study of these various contacts it is evident that the uralite porphyrite formation is younger than the gray granite and the schists, but older than the red granite. Since the gray granite pierces the schists the latter are the oldest formation. The sequence of formations in order of relative age is therefore as follows:

1. Phyllites and schists.
2. Gray granite and associated diorites.
3. Uralite porphyrite and associated rocks.
4. Younger red granite.

At the time of the extravasation of the uralite porphyrite the schistose rocks had already been folded, and so deeply eroded that the underlying granitic masses were exposed. It is probable, however, from the fact that the uralite porphyrite sheets are so often found in contact with the schists and phyllites, that the latter were not extensively or completely folded up at the time of the outflow of the volcanic rocks, and that a great portion of the disturbance was effected after that event so that the porphyrites were effected by it.

The red granite traverses the uralite porphyrite in numerous places, but the contact metamorphism is insignificant, and the alteration of the volcanic rock is, as above stated, ascribed rather to agencies attendant upon crust crumpling forces.

A perusal of the paper suggests some interesting points of analogy with the geology of the somewhat similar regions of Canada. For instance the horizontality of the Cambrian of Finnland is comparable with the flat undisturbed attitude of the Animikie rocks of lake Superior. The absence of any observable basement for the altered schistose sedimentary formations and the occupancy of the place of that basement by an irruptive and younger granite appears to be very analogous to the conditions which obtain in central Canada, as observed by Dr. A. C. Lawson, in British Columbia as described by Dr. G. M. Dawson, and in Nova Scotia as inferred from the descriptions of Mr. Faribault. The gneissic character of the irruptive granites is also another feature which the rocks of Finnland and Canada have in common. And the establishment of the existence of true volcanic rocks, though much altered, in the Archæan of Finnland is in harmony

with the conclusions which have been reached regarding the character of many of the rocks of the Keewatin (Archæan) group in the region northwest of lake Superior.

EARLIEST MAN IN AMERICA.

The AMERICAN GEOLOGIST, Vol. VIII., p. 180, September, 1891, and the *American Naturalist*, Vol. XXV., pp. 991 and 1034, November, 1891, note the important additions that have been made to our knowledge of ancestral human types by the discoveries of MM. Lohest and Fraipont, of Liège, Belgium. These discoveries, together with similar discoveries at Canstadt and elsewhere in Europe, establish the fact that the anomalous cranium, known as the Neanderthal skull, which has been discussed with more or less energy since 1857, represents a race of men once widely distributed throughout Europe, and not, as has been over and over again suggested, a mere individual peculiarity. The object of this note is not to discuss these discoveries, but to point out the fact that America was once occupied by a race of low-browed men, that were in all respects as degraded as the men of Neanderthal or Canstadt.

Dr. J. W. Foster* was among the first to call attention to the fact that tumuli in the Mississippi valley furnished crania characterized by great development of the supra-orbital ridges, low, retreating forehead, and zygomatic arches projecting beyond the general contour of the face. The skull from "Kennicott's mound," near Chicago,† had it been found in Europe, would be regarded as a fairly typical cranium of the Neanderthal or Canstadt race. A cranium from the region of Dubuque, Iowa, is equally as flat and as destitute of forehead as the famous Neanderthal skull. Dr. Lapham, speaking of the peculiarities of two skulls preserved at Milwaukee, Wisconsin, refers in particular to the "low forehead, prominent superciliary ridges, the zygomatic arches swelling out beyond the walls of the skull, and especially the prominence of the occipital ridge."‡

Four crania exhumed and described by Mr. C. L. Webster belong to the same degraded type. One of these from near Floyd, Iowa, is figured in the *American Naturalist*, Vol. XXIII, Plate

*Pre-historic Races, Chap. VIII.

†Foster's *Pre-historic Races*, p. 280.

‡Private correspondence of Dr. Lapham quoted by Foster. *Pre-historic Races*, p. 290.

VIII, Figs. 1 and 2. Three others were from Old Chickasaw, Iowa, and are referred to on page 650, of same volume of the *Naturalist.* Mr. M. W. Davis, of Iowa City, Iowa, has a cranium taken from a mound in Johnson county, which exhibits many of the same racial characteristics. Skulls of the same type are known from Indiana. In fact a low-browed, ape-like race of men was as fully developed and as widely distributed in America as in Europe.

There is reason also to believe that man was present in America at as early a period as the first record of his appearance in Europe. The arrow points found by professor Aughey in undisturbed beds of Loëss* at different points in Nebraska and Iowa, attest the presence of man in the Missouri valley in close proximity to the edge of the retreating glaciers. The human implements found in the *Equus beds* of the basin region indicate the presence of man in Nevada about the time he made his appearance in Iowa and Nebraska.

The early low-browed American had for contemporaries an assemblage of animals similar to those with which the Neanderthal man was associated. The *Equus beds* contain remains of two or three extinct horses, an elephant similar to the hairy elephant of Quaternary Europe, a musk-ox, *Ovibos cavifrons* Leidy, and others for which see the writings of Cope,† Russell‡ and Gilbert.§

Some recent discoveries in South America point to a race even more ancestral than that indicated by the flat crania of the Mississippi valley. The question may now arise whether man did not originate on the American continent. The eastern continent received its horses and camels from America; why may it not also have received from the same source its earliest stock of flat-skulled men?

Companions of Eozoon.

The constant recession of the beginning of life to lower and lower horizons, is like the constant retreat of the rainbow before the boy who follows it in the hope of finding the promised pot of gold. Most geologists of middle life can recall the time when the lowest fossiliferous strata were those lying about the base of the Ordovician or Lower Silurian system. Below this was a chaos,

*Hayden's Annual Rept. of the U. S. Geol. & Geog. Survey of the Territories for 1874. Washington, 1876. p. 255.

†Bulletin U. S. Geol. & Geog. Survey of the Territories. Vol. V. p. 48. Am. Naturalist, Vol. XVI. p. 194.

‡Fourth Ann. Rept. U. S. Geol. Survey, p. 460.

§Lake Bonneville, U. S. Geol. Survey. Monographs, I. p. 394.

not indeed without fossils but in which fossils were exceedingly scarce.

Now, however, the immense Cambrian system has been erected in this chaotic region with its three divisions, each holding a characteristic fauna, and geologists are venturing on yet farther conquests in the same direction. The vast Pre-Cambrian masses intervening between the Cambrian and the true Archæan are becoming more and more a field for careful investigation, and slowly we are finding traces of forms of lowly life that inhabited the ancient seas wherein those rocks were formed.

Behind these æons of Pre-Cambrian time lie the Archæan ages, and even these are not too old to yield traces of life. For thirty years has the spectral *Eozoon canadense* stood before the world as a palæontologic problem; on one hand stoutly defended by its foster father, Sir William Dawson, and a few faithful friends, and on the other attacked by almost all other students of the Foraminifera. In the report of Dr. Frazer to the International Congress in 1888, as given in this magazine for September of that year, are the opinions of fourteen geologists, of whom only three, Dawson, Hunt and Walcott, pronounced in its favor.

It is scarcely possible to doubt that not a few of these were influenced against Eozoon by its loneliness. Standing solitary as the single relic of the life of the dim and distant Archæan, it was surrounded with a haze that no geological telescope could entirely pierce. For this reason it was exposed, and naturally so, to suspicion that would not have been felt had other organisms of similar date been known or even suspected.

From this point of view some of the recent work of Canadian geologists is of very great interest. In his address as president of the Natural History Society, of New Brunswick, Mr. G. F. Matthew has reported some remarkable discoveries among the Archæan rocks of Canada. After noticing several connected matters, Mr. Matthew says:

"It is with pleasure that I am able to call your attention to the existence, in your neighborhood, of remains of organic forms of an antiquity far antedating the Cambrian age.

"As we have at St. John a definite base to the Cambrian system, and since these basal rocks carry the very oldest Cambrian fauna known, we are sure of the greater antiquity of the organic forms to which I refer.

"The rocks have been described in the reports of the geological survey of Canada, as the "Upper Series" of the Laurentian area, and in this the fossils to which I refer have been found."

In a subsequent paper read before the same society, Mr. Matthew described these organisms. The first which he has named *Archæozoon acadiense* is, he says, more nearly related to the *Cryptozoon* of Prof. Hall than to Eozoon, but differs from both. To the naked eye it resembles pieces of fossil wood, and it occurs in immense numbers in a reef of limestone.

Again in a later paper Mr. Matthew describes some other forms. One is *Cyathospongia? eozoica* and consists of parallel and forked spicules crossed by others at right angles or nearly so. The other is *Halichondrites graphitiferus*, also a sponge, the spicules of which occur in immense numbers on the surface of the graphitic shales of the Upper Laurentian rocks of St. John, N. B.

The importance and interest of these venerable fossils it is difficult to overestimate. If sponges and Foraninifera have come down to us from the Upper Laurentian rocks there is less reason to be sceptical regarding the organic nature of Eozoon, if the Archæan seas were tenanted by such creatures we may yet hope one day to have a fauna and flora of reasonable abundance from these old and crystalline limestones and their metamorphosed shales. We can no longer say that Eozoon stands alone a solitary relic, and scepticism on this ground has no longer any logical standing-place.

There remains, however, still unsettled the question of the age of this "Upper Laurentian," or so called Archæan. Recent studies in the "Archæan" in the United States have shown that much of the limestone and quartzite, which by geologists thirty and forty years ago, were placed in the "Laurentian," or more frequently in the "Upper Laurentian," belong in the primordial zone. This evidence is not only stratigraphic, but is also paleontologic. On this recourse the opponents of the Eozoon may still object to its Archæan age, if not to its assumed organic origin.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geological Survey of Missouri. ARTHUR WINSLOW, state geologist. **Bulletin No. 5 contains: The age and origin of the crystalline rocks of Missouri, ERASMUS HAWORTH, and Notes on the clays and building-stones**

of certain western-central counties tributary to Kansas City, G. E. LADD.

Mr. Haworth apparently reverses at once the prevalent idea of the origin of the crystalline rocks of Missouri. Formerly Prof. Pumpelly had represented them as largely or wholly derived from sediments, and Swallow had only admitted the granites and the porphyries to be eruptive. Mr. Haworth notes in the field the following evidences of their eruptive origin, (1) absence of true bedding, (2) flow and banded structure and lithophysæ, (3) breccia, (4) scoria and amygdaloids, (5) tuffs, (6) absence of gradation of crystalline into non-crystalline rock. The petrographic evidence he discusses under the following divisions, (1) texture of the ground mass in the porphyries and breccias, (2) flow structure in the porphyries and breccias, (3) broken crystals due to flowage of the lava after the crystals were formed, (4) Magmatic corrosion of porphyritic crystals and of fragments in the breccia, (5) amygdaloids, (6) absence of metamorphic minerals.

The rocks, taken together, he accepts as "Archean," but he does not define Archean. When it be remembered that "Archean" has been made, very generally, until quite recently, to embrace all crystalline rocks below the Lower Silurian, but that there is a complex of primordial crystallines, as lately demonstrated in Minnesota and New Jersey, which has an important bearing on the limits of the true Archean, it would have been well if Mr. Haworth had gone a step further, if possible, and indicated whether it is not likely that the crystalline rocks about Pilot Knob belong to the crystallines of Taconic age. Their lithology seems to exclude them from the true Archean, and to point to the Labradorian, or eruptive age of the Taconic.

Descriptions of Four New Species of Fossils from the Silurian Rocks of The Southeastern Portion of the District of Saskatchewan. By J. F. WHITEAVES. This small pamphlet of ten pages and one plate is reprinted from *The Canadian Record of Science.* April, 1891. The fossils described were discovered by Mr. J. B. Tyrrell while making explorations for the Geological Survey of Canada. The localities are on Cedar lake and on the Saskatchewan river below Cedar lake. The horizon is Upper Silurian. The species are *Strophomena acanthoptera, Pentamerus decussatus, Gomphoceras parvulum, and Acidaspis perarmata.*

Contributions to Canadian Micro-palæontology. Part III. By PROF. T. RUPERT JONES, F. R. S., F. G. S. The sub-title of this paper, *On some Ostracoda from the Cambro-Silurian, Silurian and Devonian Rocks,* fully expresses its scope and object. There are forty-one pages of text and four plates.

Laboratory Practice, a series of experiments on the fundamental principles of chemistry. A companion volume to "The New Chemistry." By JOSIAH PARSONS COOKE, LL.D. 12 mo, 192 pp., 1891, D. Appleton & Co., New York.

This little book is what it purports to be: the chemical principles are demonstrated by simple experiments, and during their performance exact observation and careful noting of all phenomena are inculcated. There are first several experiments with water, demonstrating its density, expansion by heat and by freezing, its distillation, conductivity of heat,

its latent heat, its conversion to steam, its solvent power and its action as a chemical agent and compound. Air is then taken as an example of aëriform matter, and the student is put through various experiments, under the guidance of an instructor to show the weight of air, its relation of volume to pressure (Law of Mariotte), its expansion, and tension in relation to heat and to its content of aqueous vapor. Oxygen, hydrogen, sulphur and indeed all the common elements are thus analyzed, together with their combinations, their properties discovered, or demonstrated, and made familiar by repeated operations and accompanying questions which present the substances in different lights. Thus all the fundamental principles also of molecular and atomic weights and their calculation are illustrated. This leads on to chemical symbols and notation and quantivalent expressions. The beginner who conscientiously pursues the course marked out cannot fail to become grounded thoroughly in the fundamental principles of chemistry, and he must conceive a sincere love for the science and a reverence for the constancy of nature's laws, if not for the simplicity with which they may be demonstrated.

Report on the geology of the four counties, Union, Snyder, Mifflin and Juniata, with descriptions of the fossil ore mines, Marcellus carbonate ore mines, Oriskany glass sand mines and Lewistown limestone quarries; illustrated by two colored geological maps. E. V. D'INVILLIERS. Report F_3, of the Second Geological Survey of Pennsylvania; a report of progress, 420 pp., 1888-1889. Harrisburg, 1891.

This adds another valuable number to that large series of publications devoted to the detailed description of the counties of Pennsylvania. The accompanying maps show that the area described is one of the most complicated in the Appalachian region of the state. Mr. D'Invilliers has wrought patiently and well, and has put his results simply yet clearly and compactly into print. The volume will bear with important testimony on the correlations which yet have to be made of the formations of the state, whether between those of New York or Virginia and those of Pennsylvania, or those of Pennsylvania within the limits of Pennsylvania. It is an important and a great service yet due to geology in America, that the elaborate survey that has been carried on in Pennsylvania for so many years under Dr. Lesley, shall be rounded out with a final report, showing some symmetry and general conclusions. The reports printed otherwise will fail of much of the good which their cost seems to warrant us to expect from them. We judge from Mr. Lesley's letter of transmittal that such a report is in preparation.

On some new fishes from South Dakota. E. D. COPE (Am. Naturalist, July, 1891, pp. 654-58). Five new species are described, *G. phyrura concentrica*, ? *Sardinius blackburnii*, *Proballostomus longulus*, Oligoplarchus squamipinnis and Mioplosus multidentatus. Mr. Cope regards their characters sufficient to exclude them from the Cretaceous. Their age is Cenozoic, but whether Eocene or Neocene is uncertain. The rock is soft and chalky, and the fossils are from the Ree hills.

On a new horizon in the St. John Group. G. F. MATTHEW (Canadian

Record of Science, Oct., 1891, pp. 139-43). By the aid of Mr. G. Stead, Prof. Matthews has found, on Navy island, in St. John harbour, abundant specimens of Dictyonema flabelliforme, in black shales of Division three (Bretonian) of his St. John group. The Tremadoc fauna, however, which is near the same horizon, is thought not to be on the island, but to the north of it, in the channel of St. John river. Associated with Dictyonema he found also the brachiopods Obolus, somewhat like O. apollonis, Obolella, Linnarssonia and a Lingula or Linguella.

The Story of the Hills, a book about mountains for general readers. REV. H. N. HUTCHINSON, 12mo, pp. 357, Macmillan & Co., New York and London, 1892. Although this is a popular work it is based on a thorough knowledge of the geology of the subject. It illustrates how vastly the popular science of the day is improved over that of a century ago. Indeed the work here put forth as adapted to general readers would have been welcomed then as an addition to technical, or at least to philosoph ical geology. It embodies in a pleasant style much of the philosophy of the formation, age, erosion and uses of mountains, volcanoes, glaciers, sedimentation, pressure and upheaval.

Correlation Papers of the U. S. Geological Survey; Devonian and Carboniferous. H. S. WILLIAMS, Bulletin No. 80, Washington, 1891.

In his consideration of the Devonian and Carboniferous rocks professor Williams discusses several problems connected with the subject, after he has given a general review of the literature. He examines in considerable detail the state of opinion regarding classification and nomenclature from the beginning of the century up to 1851. The Wernerian system, based upon mineralogical characters, long retarded the advance of geological knowledge, and it was only after the completion of the report of the geological survey of New York that the science advanced with any rapidity. The New York geologists, following the methods of Sedgwick and Murchison, finally gave to the world the "New York system," which, although somewhat defective, established a standard for the rocks of this country.

Prof. Williams advocates the separation of the study of the geologist and the paleontologist; he believes the work of the former should be to carefully observe the characters of the formations, describe their various features, preserve their fossils and so arrange his observations that "distinct association will be found in the name applied to each formation with the observations actually made in the field. The refererence," he says, "of each particular formation to a place in some standard scale should not be made without careful study. This careful study cannot be made independently of the fossils, for fossiliferous rocks, and in order that the paleontologist may make his studies without prejudice, the names of the formations, their localities, and their petrographic characters should be described and recorded, quite independently of the fossils which they contain." (p 55.)

The use of the term "New York system" is argued against inasmuch as it is considered an imperfect division of geological time. He advo-

cates the addition of the Coal Measures of Pennsylvania, and then a natural group of the first order would be produced, nearly equal to the Paleozoic era. "Were we to adopt for this grand terrane the name *Appalachian group*, we should have a properly constituted name for an actual, existing geologic group, free from theory, and its use would probably assist in the progress of science." (p 60.) He would discard certain lithological names still used in classifications, as *age* can never be determined by lithological characters. "It can be indicated only by that which changes with time under the influence of some definite law, and fossils alone have this value."

In addition to his disbelief in the value of lithological features in determining the age of rocks, Prof. Williams has but little faith in what is called "persistent parallelism of strata," without the aid of fossils. He points out several erroneous correlations made by this "parallelism." One of these was by Hall who, claiming he had traced the rocks step by step from New York to the Mississippi valley, stated that the Waverly sandstone of Ohio was the same as the Chemung and Portage groups of New York. (p. 63.) Other mistakes were made by the geologists of the Second Pennsylvania Survey, who, assuming an average direction and rate of dip, identified formations by their altitude. The outcrops were followed from ravine to ravine or from quarry to quarry, and though the same method was pursued by both Mr. White and Mr. Carll, when the correlations reached Chautauqua county it was found that Mr. White correlated the Panama conglomerate with the third oil sand of Venango county, while Carll placed it entirely below the Venango oil group. Prof Williams says:

"The fact seems to be, as we review the records of the survey, that the data of lithologic character of rocks and of thickness of the deposits were so constantly variable that the 'theory of persistent parallelism of strata' was little more than a theory, the exceptions to which were as numerous as the illustrations. It was a cut-and-try system of matching together innumerable sections made up of irregular combinations of shales, sandstones, conglomerates, and limestones of various color, thickness, and texture. Whenever the gaps were over a mile or two long the adjustment of the theoretical dip, a few feet more or less to the mile, would enable the parallelism to fit any particular stratum in a given section. The fact that those who showed evidence of having noted the fossils, although they may not have identified them, were invariably nearer right than those who neglected them, strengthens the belief that the fossils, even in this case, were the most valuable means of correlation." (pp 111-112.)

Among the various problems discussed we find the differentiation of the Carboniferous system: the Coal Measures or Pennsylvanian series: the Lower Carboniferous of the Appalachians and of the Mississippi valley: the Chemung-Catskill problem: the Waverly problem: and the Permian problem. The use of the name "Carboniferous" is considered unfortunate, and Prof. Williams advocates its abandonment in favor of the "Pennine system," inasmuch as it is in the Pennine chain of hills

that the typical Carboniferous section is found. (p. 81.) The limits of the system here are well defined both above and below, but in other places it shades off into the Devonian below or the Permian above. In these cases an arbitrary line must be drawn to indicate the limits of each.

Again in the discussion of the Lower Carboniferous strata of the Mississippi valley, it is proposed to use the term *Mississippian series* in place of the old name Subcarboniferous, upon the ground that the old name is inappropriate, and was "introduced as an expression of confusion and dissatisfaction with the correlations attempted." (p. 142.) This is a slight modification of the late Dr. Winchell's term Mississippi, applied by him to the same series of strata. American geologists have not hitherto fallen in with the recommendation, and they may be slow to follow Prof. Williams in both of these proposed changes. The scheme proposed for the Subcarboniferous rocks of the Mississippi valley is as follows:

MISSISSIPPIAN Series. (Subcarboniferous.)	Genevieve Group..	Chester. St. Louis. Warsaw (in part).
	Osage Group.......	Keokuk. Burlington.
	Chouteau Group...	Chouteau lime-stone and the "Vermicular" and "Lithographic" formations of Broadhead.

In the chapter on the Permian problem the conclusion is reached that as far as the strata of Kansas and Nebraska are concerned there is no Permian system, the passage from the Coal Measures being gradual and not abrupt. The application of the term is here considered purely artificial, and induced by those who sought to force a correlation between the rocks of Europe and America. As for the Permian ranking as a separate system he says it is still an open question, "and bids fair to continue so until a natural method of classification for the time-scale be devised, which shall be independent of the lithologic character of the rocks." (p. 209.)

The general remarks and conclusions are well worthy of careful perusal. That to paleontology is given the first place in all correlations is evident throughout the work. We have already shown his opinion of the theory of "persistent parallelism of strata" and it is reiterated on page 263. Here, also, he refers to the value of fossils, correlations by their aid being based upon actual evidence, which can be corrected by a critical review; while the particular form of any organic structure is considered determined by heredity and environment. "Hence we may deduce the law that, given the locality and the conditions of environment, the fossil has in itself the evidence of its geologic age." (p. 263.) In the Mississippian province he advocates a structural and a time scale of formations. From the first point of view there should be an increase in the number of formations: while from the paleontological standpoint the classification is too minute and the number of formation should be reduced.

A new feature is introduced in the consideration of geographical features as modifying geological classification, but it is not elaborated to

any extent. It having been demonstrated that classification cannot be based upon the uniformity of lithological constitution, and that uniformity of stratigraphy cannot be relied upon for correlations "the modern school of paleontologists are demonstrating the fact that the divisional lines marking the biologic or time scale do not correspond to those of the structural or stratigraphic scale, but are determined by independent factors. In the classification of rock formations the character of the formations should receive chief consideration, but the particular geologic period in which the sediments are deposited has practically no relation to the nature of the sediments or their amount or their physical arrangement as geologic deposits. It is, hence, a grave question whether the development of our science does not demand that geographic factors should take precedence of time factors in all classifications of geologic formations." (p. 267.)

The standpoint of the new school of paleontologists of which professor Williams is an able exponent, is summed up in the concluding paragraph of the Bulletin. According to the Darwinian idea of species, as opposed to the Cuverian, "the modification of organic form is conceived as not an arbitrary matter, but as correlated with difference of environment and of genetic relationship, so that the lesser variations of specific form are of as great value to the modern paleontologist for purposes of correlation as is the identity of species. Comparison of allied species in the same genus exhibits to him the rate and direction of modification taking place in the genetic history of the genus, and in the plastic or variable characters he finds a sensitive indicator of the stage of development attained by the race when the particular individual lived. Biological study shows him that the fossils must contain intrinsic evidence of their geologic age independent of the formations in which they were buried, and his chief work is to learn what this evidence is and how to interpret it. To such evidence the final appeal must be made in all cases of the correlation of geologic formations." (p 269.)

Taken as a whole the Bulletin under review cannot but be regarded as a valuable contribution to the philosophy of geology; and while some of the conclusions of the author may not meet with the approval of all, they at least merit consideration. Some portions of the volume show signs of haste in preparation; and it would have been a valuable addition had there been given a list of the books and papers consulted or referred to in the course of preparation of the Bulletin.

RECENT PUBLICATIONS.

I. *State and Government Reports.*

Annual Report of the Geological Survey of Arkansas, 1888. Vol. IV. Part I. Geology of Washington County; Part II. List of the Plants of Arkansas.

Ditto, 1890. Vol. I. Manganese: Its Uses, Ores, and Deposits. By R. A. F. Penrose, Jr.

Annual Report of the Geological and Natural History Survey of Canada. Vol. IV. (N. S.) 1888-89.

II. *Proceedings of Scientific Societies.*

Proceedings of the Academy of Natural Sciences of Philadelphia, 1891. Part II, April-August, contains: Echinoderms and Arthropods from Japan, by J. E. Ives; Notice of Some Entozoa, by Joseph Leidy; Note on Mesozoic Mammalia, by O. C. Marsh; Fossil Faunas in Central Iowa, by Charles R. Keyes; On Paramelaconite and the Associated Minerals, by G. A. Koenig; Echinoderms from the Bahama Islands, by J. E. Ives; Memoir of Joseph Leidy, by H. C. Chapman; Mollusca from Nantucket, Mass., by H. A. Pilsbry; Geological Features of the Meteoric Iron Locality in Arizona, by A. E. Foote.

III. *Papers in Scientific Journals.*

Am. Jour. Sci *Aug. No.* contains: Some features of the non-volcanic ejections as illustrated in the four "rocks" of the New Haven region, West Rock, Pine Rock, Mill Rock and East Rock, James D. Dana; Notes of a Reconnaissance of the Ouachita mountain system in Indian Territory, Robt. T. Hill; Note on the asphaltum of Utah and Colorado, by Geo. H. Stone; A gold-bearing hot spring deposit, Walter H. Weed; Restoration of Stegosaurus, O. C. Marsh.

Sept. No. contains: Pleistocene fluvial planes of western Pennsylvania, Frank Leverett; Genesis of iron ores by Isomorphous and Pseudomorphous replacement of Limestone, etc., James P. Kimball; Constitution of certain micas, vermiculites and chlorites, Clarke and Schneider. A further note on the age of the Orange Sands, R. D. Salisbury; Note on the causes of the variations of the magnetic needle, Frank H. Bigelow; Notice of new vertebrate fossils, O. C. Marsh.

Geol. Mag. *August No.* contains: Glacial geology, G. W. Bulman; The Pleistocene beds of Gozo, J. H. Cooke; On orthoceratites vaginatus *Schloth.*, Arthur H. Foord; Physical studies of an ancient estuary, A. Irving; On the British earthquakes of 1889, C. Davison; The age of the Himalayas, W. T. Blanford. *Sept. No.* contains: Restoration of Stegosaurus, O. C. Marsh; The Scandinavian glacier and some inferences derived from it, T. F. Jamison; Transverse valleys in the eastern Caucasus, Hjalmar Sjögren; On the sands and gravels in the boulder-clay, G. W. Bulman; Recent geological investigations in the Salt range, India, A. B. Wynne; Rock specimens from Kimberly, Prof. Bonney and Miss C. A. Raisin, with a note by T. Rupert Jones; Glacial mound in Glen Frain, Dugald Bell. *Oct. No.* contains: On the origin of concretions in magnesian limestone, E. J. Garwood; Elevation of the American Cordillera, H. H. Howorth; On the British earthquakes of 1890, C. Davison; On the lower Greensand and Purbeck beds, P. B. Brodie; The lower Greensand or Vectian in Dorset, A. J. Jukes-Browne; On color-bands in *Waldheimia perforata*, Edw. Wilson; Note on the Coniston Flags, W. M. Hutchins.

CORRESPONDENCE.

THE MIDDLETON FORMATION OF TENNESSEE, MISSISSIPPI AND ALABAMA; WITH A NOTE ON THE FORMATIONS AT LAGRANGE, TENNESSEE. The party of geologists, spoken of on page 408, Vol. VIII, of this journal, stopped in their travels, for a couple of days, at Oxford, the site of the University of Mississippi. The chief object was to inspect the fossil plants, collected in Mississippi and now in the museum of the University. While there, observing, with the other members of the party, the many interesting specimens, I happened upon a lot of peculiar rock fragments, containing casts of fossils, which had a very familiar look and which I thought must have come from some one of certain localities in Tennessee. I at once called Dr. Hilgard's attention to them. "No," he says, "they are from the Reeve's locality in Tippah county of this state, and from the 'clay sandstone' found there." He then referred us to page 112 of his "Agriculture and Geology of Mississippi," where a section of the rocks at Reeve's is given. "The clay sandstone is No. 2 of the section and from this the rock-fragments in question came." Dr. Eug. Smith, who was standing near, recalled the fact that the same rock occurs in Alabama.

All this was a revelation to me. I had known the rock for many years in Tennessee, and did not know of its occurrence elsewhere. With us, it is found at a number of localities. One is on the Memphis & Charleston railroad, at Middleton, in Hardeman county. An extensive outcrop of the rock is seen along the Bolivar and Purdy dirt road. It begins about eight miles from Bolivar and extends easterly two miles, or thereabouts, and nearly to Wade's creek. This is also in Hardeman county, through which county, indeed, the formation outcrops in a belt running north-northeasterly and south-southwesterly.

The rock referred to, is one of the most characteristic of a group of layers. It is about two feet thick, a sort of conglomerate, consisting of lumpy clay mixed with sand, and more or less consolidated into a bluish gray mottled mass. It contains also green, glauconitic grains and casts of fossils. Dr. Hilgard, in the section referred to, speaks of it as "clay-sandstone, spotted blue and yellow, with green grain dots." The fossils he mentions as occurring in it are "*Venericardia planicosta, Cardium nicolleti? Trochus, Ostrea, etc.*"

The particular rock described is one of a group, or formation, which is evidently the lowest division of the Eocene of this region.

From the interest attached to this group and the very considerable extension it proves to have, it deserves a distinct name. Drs. Hilgard and Smith approving, I have named it the *Middleton formation* from the name of the town where its outcrop is intersected by the Memphis and Charleston railroad.

Immediately to the east of the formation, in Tennessee, lie the Cretaceous (Ripley) beds, while to the west are the Flatwoods (Porter's

Creek) clays. The formation will be further considered and reported upon hereafter.

Another place visited by the party mentioned above, was the noted La Grange locality in Fayette county, Tennessee. Those of the party visiting this point, in addition to the gentlemen already referred to, were Messrs. McGee, Ward, Hill and Holmes. All were much interested in the great display presented here. La Grange is located on the edge of a high table-land. Immediately to the south of the town, this table-land breaks away in a steep, bold escarpment down to the bottom-lands of Wolf river. The washes along the old roads leading from the town down the escarpment have displayed in grand sections the strata of the region.

The Lafayette (Orange Sand) formation makes up by far most of the slopes. At the base of the slopes, come in a group of laminated sands and clays, with shelly, siliceous shales and sandstones containing leaves, which it was agreed pertain to the La Grange formation. At the top of the slopes and sections, making the floor of the table-land and resting upon the Lafayette, is the "Yellow loam," a division of Mr. McGee's Columbian formation.

I add that the La Grange formation, which is so low in the sections at La Grange, rises, at points in Fayette and adjacent counties, to much higher levels, even appearing and outcropping, now and then, at the surface of the table-lands. The La Grange had an uneven, more or less eroded, surface upon which the sands of the Lafayette were deposited.

JAMES M. SAFFORD.

Vanderbilt University, Nashville, Tenn.

BIBLIOGRAPHY UNDERTAKEN BY THE INTERNATIONAL CONGRESS OF GEOLOGISTS.—Mr. G. K. Gilbert communicates to the GEOLOGIST the following letter from Mr. Em. de Margerie, Secretary of the International Committee on the Bibliography of Geology. It sets forth the organization and plans of the Committee. Geologists residing in North America who have prepared or are preparing bibliographies of any portion of the literature of geology, are requested to communicate with Mr. Gilbert (address: G. K. Gilbert, U. S. Geological Survey, Washington, D. C.)

INTERNATIONAL CONGRESS OF GEOLOGISTS: COMMITTEE ON THE BIBLIOGRAPHY OF GEOLOGY.

Paris, Rue de Grenelle 132, Nov. 20, 1891.

Sir: At the meeting of Tuesday, September 1, 1891, the International Congress of Geologists, assembled at Washington, on motion of Messrs. H. S. Williams and de Margerie, appointed a permanent international committee charged with the duty of centralizing the information relating to geologic bibliography. This committee, which is authorized to add to itself new members in unlimited numbers, comprises at present Messrs. Frech (Germany), Gilbert (North America), Golliez (Switzer-

land), Gregory (England), de Margerie (France), Reusch (Scandinavia), Steinmann (South America), Tschernyschew (Russia), Tietze (Austria-Hungary), and Van den Broeck (Belgium).

The end to be attained is threefold: (1) to prepare a list of the geologic bibliographies already in existence; (2) to prepare an inventory of those parts of geologic literature, which have not as yet been the subject of such methodic abstracting, in order to prepare the way for undertaking, comprehensively, the retrospective bibliography of the science; and (3) to proceed to the periodic registration of its current bibliography.

The first meeting of the committee took place during the excursion to the Rocky Mountains. The following are its minutes:

"The International Committee on the Bibliography of Geology met September 20, at 8 o'clock in the evening, in one of the cars of the special excursion train, between Manitou and Denver (Colorado). Present, Messrs. Frech, Gilbert, de Margerie, Reusch, Steinmann, Tschernyschew, Tietze and Van den Broeck. Prof. H. S. Williams also was present at the meeting.

"Mr. Gilbert was by acclamation elected President of the Committee, and Mr. de Margerie, Secretary. Mr. de Margerie will take charge of the correspondence for Europe, and undertakes to transmit to Mr. Gilbert all the documents intended for printing.

"In regard to retrospective bibliography, Mr. Golliez announced to the committee that the Geological Survey of Switzerland, is preparing a geologic bibliography of Switzerland, which it will probably take several years to complete. Mr. Tschernyschew announced the existence of a catalogue of the same nature on the North of Russia, as yet unpublished, of which he is the author. Finally, Mr. Van den Broeck called attention to the general bibliography of Belgium, which is to comprise a list of all documents relating to the geology of that country published in the course of the 19th century.

"After a short discussion, the committee decided to confine its efforts for the time being, to the preparation of a list of the partial geologic bibliographies already in existence. Each member of the committee is to perform that part of the work which relates to the country he represents. For Spain, Italy and Portugal, which countries sent no representatives to Washington, the committee will address itself to the directors of the geological surveys of these three states. Mr. Tietze agrees to take charge of the bibliography of the Balkans, and Mr. de Margerie will try to fill out any gaps that may exist in the collection of documents gathered by the various members of the committee as regards Asia, Africa and Oceanica. The manuscripts must be sent to the Secretary before Easter, 1892, in order to be printed with the proceedings of the Washington meeting.

"The projected list will comprise the detailed titles of works entering into the following categories:

"(1) *Regional or local bibliographies.* (Examples: Geologic Bibliography of Italy; Geological bibliography of the counties of England, by Whitaker; Catalogue of the publications of the American surveys, by Prime.)

"(2) *Systematic bibliographies*, that is to say, relating to a defined group of facts. (e. g. Bibliography of the various classes of rocks, inserted in Rosenbusch's Petrography; Bibliography of the upper Jurassic, by Neumayr; glaciers, volcanoes, etc.)

"(3) *Personal bibliographies.* (Catalogues of the geologic publications of one author, like those that often accompany necrologic notices; Royal Society's catalogues of scientific papers, etc.)

"(4) *Catalogues of geologic maps.* (e. g. Mapoteca geologica Americana, by Marcou.)

"(5) *Annual geologic bibliographies* either general (e. g. Geological Record: Revue de geologie, by Delesse and de Lapparent; Annuaire geologique, by Dagincourt). or special (e. g. Revue geol. Suisse, by E. Favre and Schardt: Bibliotheque geologique de la Russie, by Nikitin; Record of American Geology, by Darton.)

"(6) *General tables of special periodicals* or series. (e. g. the Repertorium to the Neues Jahrbuch fur Mineralogie; Index to the publications of the Geological Society of London, by Omerod; Table of Paleontographica; List of the geological maps published in the Quarterly Journal, by R. Bliss.)

"(7) *Printed catalogues of special libraries.* (e. g. Catalogue of the library of the Geological Society of London. Catalogue of geologic works found in the libraries of Belgium, by Dewalque.)

"As regards the scope to be given to the work, the committee thinks proper for the present to exclude all documents of purely mineralogic or paleontologic nature; on the other hand, information relating to petrography, physical geography, applied geology, mineral waters and prehistoric archeology will be included. For the rest, full latitude is left in this respect to the collaborators, the editor being empowered to extend or abridge manuscripts with a view of securing proper uniformity in publication.

"Important manuscript bibliographies, the existence of which may be known to the members of the committee, are to be indicated in the proper places, stating name and address of author.

"The publication will be in French, but manuscripts may be prepared in the language of the country whence they come, to be translated afterward under the direction of the editor.

"Titles must always be given in the language of the original publication; they will not be followed by a French translation except in case they belong to a language other than English, German, Italian or Spanish. The indication of the author's name, place of publication (with the publisher's name in the case of a separate work), date, size and number of pages, shall be as exact and detailed as possible: furthermore it is desired to have stated the approximate number of entries contained in each bibliography, adding summary information regarding its nature, such as: 'Alphabetic catalogue by authors' names; Catalogue classified by order of dates; Simple list of titles; Each article is followed by a resume; The number of plates is not given; etc.' The limiting dates of

the publications catalogued in the bibliographies are also to be noted. (e. g. 1802 to 1888.)

"In case a bibliography bears no printed title, which often happens with such as are appended to special works or memoirs, it will be proper to define its subject by means of a phrase *in brackets*: [....], giving after this the complete title of the document in which the bibliography is comprised.

"Publications which, without pretending to take the form of a methodic bibliography, contain the detailed history of the study of a question of general interest or of a country, are to be mentioned.

"In order to facilitate the final classification of subjects for the purpose of printing, the collaborators are requested to prepare their work on separate slips." The Secretary,

EMM. DE MARGERIE.

To Mr. G. K. Gilbert, Member of the Committee for North America.

PERSONAL AND SCIENTIFIC NEWS.

PREHISTORIC HORSES.—The genealogy of the horse has been most admirably worked out in various publications, and the fact has long been established that the genus originated on the North American continent. The question, however, as to whether prehistoric man in America had the horse as a contemporary has been a disputed point. This question may now be considered set at rest by the discovery of a skull of an extinct species of horse in strata with human implements.

This discovery was announced by Prof. E. D. Cope at the last annual meeting of the American Association for the Advancement of Science. A skull of a horse was exhibited to the members by Prof. Cope, who pointed out the characters of the teeth and who stated it would be impossible for any one to separate the fossil teeth from those of the quagga and zebra if the three were all thrown together. In minor characters, such as those of the size of the bones, the differences are preceptible. So there is no doubt the skull represents an animal different from any now living. That it was a horse, however, any one could see.

The most curious thing about the skull was its condition. The frontal bone had been crushed in exactly as we see in the case of animals slaughtered for food. The friable bones protecting the eye sockets were intact, as were also the long nasal bones. Found in the same bed with the skull was a stone hammer that bore evident marks of having been fashioned by the hand of man.

What inference was to be drawn from this? In the first place it has been suspected and considered probable that early man on this continent had been contemporaneous with a horse, though not the present living species, but no direct proof had hitherto

been found. When Europeans landed on the new continent the horse was an unknown animal to the natives. So it had evidently long been extinct.

All the horses now found in either North or South America came from stock originally brought over by Europeans. But here we have evidence in the association of a human implement and a horse's skull that man and horse had lived together, and the peculiar fracture of the skull of the latter leads to the belief that the animal had met its death at the hands of man.

This fact opens several questions. What became of the race of horses that once lived on the continent? Were they exterminated by savage man as civilized man has exterminated the bison? Did they once serve as beasts of burden or were they used only as food? Were they wild or domesticated?

It seems probable that they were not used for any other purpose than as food, and that they existed only in a wild state, for it is scarcely reasonable to suppose that having once been used by man and so domesticated their use would ever have been forgotten or the breed allowed to die out. Neither is it probable that they were exterminated solely by the agency of contemporaneous man, for we know that in spite of the use of the bison by the Indians of North America their numbers did not decrease to any great extent. It was only when civilized man began his destructive work that the bison began to disappear.

What then was the cause of the disappearance of the horse? If it were demonstrated that this early horse existed prior to the ice-age his disappearance might be attributed reasonably to the cold that prevailed, or to some of the attendant conditions. While Dr. Cope considers the "Equus beds" as of Tertiary age, Messrs. Gilbert, Russell and McGee have given much evidence that they are middle or late Quaternary. The coördination of the strata of the southern states with the drift sheet of the northern has not yet been elucidated. The early Pleistocene was connected by a link which has not yet been discovered, with the latest Pliocene. Whether that link consisted largely of the advent of the ice-age, or the outburst of the Quaternary eruptive forces that characterize this date in the western and Pacific states, or both of these cotemporaneously, it is evident that it was marked by great physical changes such that the habitability of the country by many of the larger mammals was destroyed.

Mr. Cope has given a description of this skull in the October number of the *American Naturalist*. He considers it *Equus excelsus* Leidy, and remarks that it is the first that has come to light in the United States.

The Spanish Government has determined to hold a historical and archaeological international exhibition next year, and especially honors the United States by its invitation and application for aid. The Spanish exposition will in no wise compromise

the success of the great Chicago world's fair of the following year. On the contrary the more perfect the first display, the better will the departments of archæology and history be represented at our own; for the Spanish government has generously proposed to transfer a large part of its treasures to our buildings during the six months which intervene between the closing of the one and the opening of the other. All persons having collections of archæological, ethnological (mumismatic), or historical material connected with the history of this country both before the discovery and after the discovery, up to 1750, are urgently invited to loan it under the safe guarantees offered by the circular of the Spanish government, forwhich apply to Señor Campillo, Sec'y of the Spanish legation at Washington.

IT APPEARS THAT GEOLOGICAL FRAUDS are not confined to this country, as the following extract from a late number of *Nature* proves. "A notice which will be read with interest by all owners of gems, has been issued by Dr. A. Brezina, of the Natural History Museum of Vienna. It relates to the doings of a young man who on September 26 contrived to conceal himself in the department just before the time for the closing of the Museum. He was caught and found to be armed with a revolver, and to have in his possession files and other implements. He had also in his possession nearly 600 gems, some of them cut, but the majority in their natural state. He has a passport, in which he is described as Hugo Kahn, of Berlin, but he has also called himself Krony, Kronek, Kornak and Kronicsalsky. His age is 24, he measures in hight 170 cm., he is slender, has a longish handsome face, is of a brownish complexion, has dark hair, grey eyes and a light brown beard, of feeble growth. Upon the whole he is an attractive looking person. He has made several journeys in Germany, France, Switzerland and Italy; and between the middle of last July and the beginning of September he travelled through Pyrmont, Ems, Strassbourg, Basel, Milan, Genoa, Nice, Monaco, Genoa and Venice to Vienna. Most of the gems (the names of which with the exception of a rock-crystal, he does not know), he professes to have bought from a barber in Marseilles. As it is important that the former owners should be known, Dr. Brezina prints a list of the gems, with a request that any one who has information about them will communicate with him." Evidently this man is not nearly so finished and thorough-going a scamp as the one lately exhibited in the rogue's gallery of the GEOLOGIST. The narrative given above well illustrates the danger to which all costly and valuable collections are exposed, when they are opened to the public, and the necessity of the utmost vigilance for their protection.

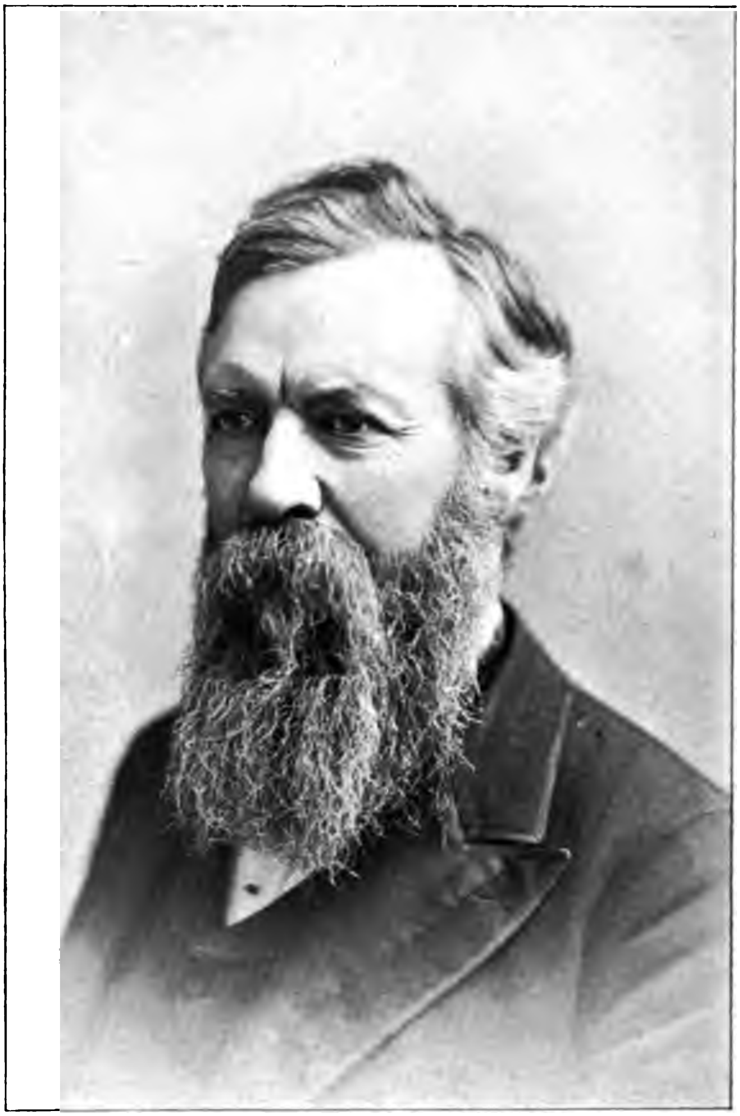
THE LATE DR. P. HERBERT CARPENTER was the fourth son of the late Dr. W. B. Carpenter, C. B., F. R. S. He was found dead in his dressing-room on Oct. 21. At the inquest it was found

that he had killed himself by the administration of chloroform during temporary insanity. Dr. Carpenter had been Science-master at Eton since 1877. The *Times* gives the following account of his scientific work: "He was a member of the scientific staff of the deep-sea-exploring expeditions of the 'Lightning' (1868) and the 'Porcupine' ('69 and '70) and in 1875 he was appointed assistant naturalist to the 'Valorous' which accompanied the Arctic expedition of Sir G. Nares to Disco I., and he spent the summer in sounding and dredging in Davis strait and the N. Atlantic. Dr. Carpenter devoted himself exclusively since 1875 to studying the morphology of the Echinodermata, especially the crinoids. In 1883 he received the Lyell medal from the Geological Society of London and in 1885 was elected a Fellow of the Royal Society. His chief papers were 'Notes on Echinoderm Morphology,' 'On the Genus Actinometra,' 'Report on the Crinoidea dredged by the Challenger,' 'The Stalked Crinoids,' 'The Comatulæ,' 'Report on the Comatulæ dredged by the U. S. Coast Survey in the Caribbean Sea,' and numerous papers in the Transactions of the Royal, Linnæan and Geological Societies."

PROF. P. WHITFIELD DESCRIBES in *Science*, Dec. 18, the discovery of the remains of a mastodon on New York island, at the eastern end of Dyckman's creek at its junction with the Harlem river, sixteen feet below mean low-water.

MR. J. W. KIRKPATRICK IN THE SAME NUMBER OF *Science*, describes the finding of a nugget of copper, also northern boulders and stræ, near Fayette, Mo., near the central part of the state, the nugget weighing 23 pounds.

THE FOURTH ANNUAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA was convened at Columbus, O., Dec. 29, 1891. The acting president was G. K. Gilbert. The numerous articles read will be noted as they may be published in the Society's bulletin.



Alexander Winchell

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THE

AMERICAN GEOLOGIST

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ALEXANDER WINCHELL.

AN EDITORIAL TRIBUTE.

NOTE. The following memorial sketch of Alexander Winchell, who died February 19, 1891, is a tribute of the AMERICAN GEOLOGIST to a deceased member of its editorial corps. As one of its founders and as its zealous friend and its most able and voluminous writer, his memory and his eminent services in the infancy of the magazine can most fittingly be commemorated by this sketch of his life and work. At the same time this account of one whose name has for the past forty years been seen frequently in geological, educational, philosophical, and even in theological literature, will satisfy not only a demand, but a just expectation which has often been expressed since his death. We are convinced also that the readers of the GEOLOGIST in general will take pleasure in receiving, in lieu of the miscellaneous contributions with which the GEOLOGIST usually is filled, this joint memorial of one whose voice, now silent forever, they have many times heard, perhaps, either in the class room or on the public platform.

I. SICKNESS, DEATH AND FUNERAL.

Probably the first apprehension of serious bodily ailment of the late Dr. Alexander Winchell, by others than himself and family, was experienced while he was in attendance at the Washington meeting of the Geological Society of America (December 29-31, 1890), where he served as the presiding officer in the absence of the president (Dana) and of the first vice-president (Newberry). Several noticed the ashen hue of his countenance, and those more intimately acquainted with him knew of a weakness of limb, and a shortness of breath with which he suffered. He persistently adhered to the discharge of his duties, however, in connection with the Geological Society, whether of an official or of a social character, and after adjournment he repaired immediately to his home at Ann Arbor, where he was inclined to remain until his strength should return. Having, however, several engagements to lecture he

remained quiet but a very few days, when he visited Highland Park (near Chicago) and Milwaukee, where he gave public lectures. Immediately on returning home again he entered on a course of four lectures on *Evolution*, delivered before the Geological Society of Ann Arbor. His weakness increased, and he could with difficulty walk to the lecture hall in the University buildings. The fourth lecture was never given, because the family physician, summoned against his protest, interposed, and before he could be restored death had put his veto upon it.

The malady with which he had suffered for many years, and which he fully understood himself, but never mentioned to his family, crept upon him very slowly to its fatal termination. He had noted for several months that he became easily wearied physically. His breathing was difficult, and he had asthmatic symptoms. Nights he slept little, sometimes being compelled to rise in order to obtain relief from hard breathing, or panting. This he attributed to heart disease, but still kept about his work. Finally, when confined to his room, and mostly to his couch, he was regretful of the time he was compelled to lose in that way. His mind apparently ran over the themes of his lectures, and he planned new topics. "You must not think I am idle, though lying here," said he, "for I have laid out two or three articles to be written." Later, the same day, he said: "I believe I can demonstrate mathematically the necessity of a modification of the nebular hypothesis of La Place." Still later he explained what he meant by the modification which should be made in the nebular hypothesis. "I believe I can show mathematically that each successive annulation was accompanied by, and caused, an enlargement of the orbits of every earlier ring; and that the various orbital diameters of the resultant planets have been enlarged from time to time, or pushed away from the residual mass." When it was remarked to him that the La Placean hypothesis required a constant shrinkage of the central mass, having once been extended to the utmost limits of the solar system, and that by loss of ring after ring it had been reduced to its present condition and size, "Ah well," said he, "let those defend that who believe it, I believe that, like an exogenous tree-trunk, the outer diameters can be shown to have been enlarged from time to time." This seems to be a new conception. It certainly would have been embraced in his "World Life," had it ever been presented before, but we

find nothing of it in that volume. The suggestion seems to be a fruitful one, and may be established or refuted by some competent physicist.

The immediate cause of death was suffocation, superinduced by dropsical secretions which permeated his whole system, and finally filled his lungs. The primary pathologic cause was *aortic stenosis*, by which the aortic orifice was so reduced that the necessary amount of blood could not pass it, deranging the whole circulation. The cause next more remote was a severe attack of "inflammatory rheumatism" in the spring of 1865, and the original cause, as traced back by himself, at the time, was long exposure, in February, to cold in working in the University museum at Ann Arbor without fire.

His old-time college friend, Rev. Wm. S. Studley, D. D., of Evanston, Ill., conducted the funeral, and delivered an appropriate and eloquent address.* The burial was in Forest Hill cemetery, Ann Arbor, where four of his children had preceded him.

His death brought forth numerous expressions of sorrow and testimonials of esteem, some of which were dispatched from points as remote as San Francisco and Boston, and from several in Europe. One came from Central America, bearing a sprig of edelweiss from the Swiss Alps. The geologists of the United States Geological Survey gave expression of their sentiment and sympathy, in the following words:

WASHINGTON, D. C., February 20, 1891.

* * * * By his unflagging devotion to science and his equally constant and successful efforts to promote and extend beneficent knowledge among men, Professor Winchell justly won the respect and admiration of his fellow-students throughout the world; and by his personal uprightness, the honorable motives manifested in his daily life, and his unfailing courtesy, he inspired the esteem and friendship of his professional associates in those scientific gatherings and institutions in which he always took so active and worthy a part.

As students of geology we deplore the death of one of the foremost geologists of the century; as personal friends we mourn the loss of one of the most highly esteemed in our circle; and in this, our common be-

*This address with several others delivered at a memorial service at the Methodist church, May 10, 1891, has been published in pamphlet form. The "University memorial," embracing the address of Prof. M. W. Harrington, May 3, has also been put into pamphlet. The memorial address delivered before the Geological Society of America, in August, 1891, by his brother, Prof. N. H. Winchell, is included in Vol. III, of the Society's bulletin, together with resolutions adopted by the Society.

reavement, our hearts go out in sympathy to the stricken family whose sorrow we share.

Signed:

J. W. POWELL,	G. K. GILBERT,
C. A. WHITE,	ARNOLD HAGUE,
MARCUS BAKER,	S. F. EMMONS,
J. S. DILLER,	W. H. HOLMES,
CHAS. D. WALCOTT,	C. WILLARD HAYES,
WM. H. DALL,	ISRAEL C. RUSSELL,
A. H. THOMPSON,	HENRY GANNETT,
WALTER H. WEED,	NELSON H. DARTON,
BAILEY WILLIS,	GARRICK MALLERY,
W. J. MCGEE,	HENRY W. HENSHAW.

The University Senate, Ann Arbor, adopted a memorial expression of the loss suffered by the University, from which the following is taken :

* * * * To some of his books it was given to guide to a degree rarely accorded to books in these days, popular thought on the subjects on which they treat. They have had an influence which few scientific books have ever reached. They have not only made their author one of the most prominent figures in American science, but have made his name a household word in thousands of families.

But we feel the loss of Dr. Winchell not only because of his eminence in his chosen field of work, but also because of his personal qualities. He was a man of impressive appearance and dignified bearing, a courteous colleague and a faithful friend, and those who knew him best found in him depths of gentleness and affection which are found but seldom. He was absolutely unswerving in his allegiance to what he believed to be the truth. With true scientific instinct he firmly believed that all truth was one, and he devoted himself for many years to proving that science and revelation could not be in conflict. His faith in ascertained science was no less unwavering than his faith in religion, and in earlier days when such an assertion provoked hostile and even bitter criticism, he dared to assert and maintain that geology and revelation were in accord. Unmoved by the storm which he had raised, firm in his convictions of scientific truth, and devout by nature, he then passed on to the study of the great problems of creation--problems to which his deeply religious feeling, his love of nature and his natural bent and grasp of mind all irresistibly turned him. With a reverent but master hand he endeavored to lift the veil of the past, to follow the steps of creation, ascertain its laws, and follow its evolution. These were the problems to which he delighted to devote himself. His other studies were only incidental to these, or to the duties of instruction. It was under the inspiration of these grand problems that his most influential books were written, and his most eloquent discourses delivered; and, as it happens, his last public lecture, the last lecture he was destined to deliver, when the feebleness of mortal disease was overcome by the inspiration of his subject, a

lecture which called together so many that his class room had to be exchanged for University Hall—that his last public address was again devoted to one of the noble problems of creation. It was a fitting subject for the last discourse, and a fitting close for the public life of so great, so able and so devout a man.

A noble and striking personality, a man of great learning and lofty ideals, has been stricken down, and we grieve at his loss; a gentle and earnest spirit has left us, and we mourn. * * *

The University Musical Society, the Ann Arbor Geological Society, the Wesleyan Guild of the University of Michigan, and the trustees of the Methodist Episcopal church at Ann Arbor, of all of which he was president, adopted similar tributes. The Hamilton (N. Y.) Theological Seminary and the Davenport Academy of Science adopted resolutions of regard and sympathy.

The Geological Society of America, of which he was also president, at its meeting in the following August, had an appropriate memorial address, delivered by his brother, Prof. N. H. Winchell, and adopted resolutions presented by a committee, of which Prof. Edward Orton, of Ohio, was chairman. The address and resolutions are published in the Bulletin of the Society for 1891.

A multitude of tributes from personal and scientific friends were received by his stricken family, but they need not here be further referred to. An extract from one simply will suffice:

My admiration for him was boundless. He was the most learned man I have ever met, and I preferred his society to that of any other American scholar. *Bishop Newman.*

II. PERSONAL HISTORY.

Alexander Winchell was born of parents in humble but comfortable circumstances, December 31, 1824, in the town of Northeast, Dutchess county, New York. The ancestral homestead, a large frame farm-house, for many years used as a hostelry by his grandfather, Col. Martin E. Winchell, for the accommodation of the travelers who passed by the stage route between the Hudson valley and the towns of southwestern Massachusetts, still standing, is surrounded by an undulating mountain plateau forming one of the spurs of the Taconic mountains, and long known as Winchell mountain. His father was Horace Winchell, fifth child and third son of Col. M. E. Winchell. His mother was Caroline McAllister, of Northeast, of Scotch-Irish ancestry, from the Protestant families of the north of Ireland. His father's descent is traceable directly to Robert Winchell, an Englishman who set-

tled at Dorchester, Mass., in 1634, and removed with the first settlers to Windsor, Conn., in 1635.* His father died in 1873, at Lakeville, Ct., at the age of 77 years. His mother still lives, at Lynn, Mass., with her daughter, at the age of 85. Some of the dominant traits of Alexander's mental, as well as physical constitution were derived from his mother.

1824. He was the first-born, and under his father's fond tuition he received not only the first elements of his education but the earliest impressions of honorable striving and achievement. His father and mother had both been teachers in the public schools of the town, and Alexander's training profited by that experience. On the day that he was seven years old he recited, without mistake, the entire "Multiplication Table" to twelves, and had completed *Emerson's First Part* of mental Arithmetic. When three months past ten he had been through *Willett's Arithmetic* (similar to Daboll's) and had transcribed all the definitions, rules, problems, and full solutions in a manuscript book, which is still extant among his papers. This early bent for mathematics remained through his entire life, and gave shape to numerous discussions and arguments.

1838. He was at first destined for the profession of medicine, and spent two years with a great uncle, Dr. Charles McAllister, in South Lee, Mass., attending the "Stockbridge Academy" in the summer and the village school during the winter. The Latin which he had begun with his father in 1837, was here resumed. In 1840, being still too young to begin the study of medicine, he visited his parents, intending to remain a year. Having one day expressed to his father a desire to teach, though not yet 16 years of age, his father immediately responded that he would obtain a position for him, and a district school was engaged, which he taught during the winter of 1840-41, his patrons supposing him to be a young man of 21. Here one of his amusements was the collection and solution of arithmetical problems. He began here the practice, continued ever afterward, of putting on record the results of his reading and study. He had already filled two volumes with arithmetical solutions and rules. Here also he began the keeping of a diary, and a strict account of expenditures, forming a habit which he never lost, and which furnishes the materials for this personal sketch.

*Genealogy of the Family of Winchell in America, embracing the etymology and history of the name. Alexander Winchell, 1869.

1841. His fondness for teaching being confirmed, he engaged another school for the summer of 1841, and during its progress he pursued, at his leisure, the study of some higher mathematics. Day's Algebra he completed by himself, resolving every equation and problem, absolutely without assistance, and writing all the results in a book. Before autumn he had also finished Davies' *Surveying*, and then Flint's *Surveying*, writing as before all the solutions in a book. During the winter engagement of 1841 and 1842 he taught Gummere's *Surveying*. In March, 1842, he joined the M. E. Church, in Pine Plains, Dutchess county, N. Y., and this membership he maintained to the time of his death.

1842. By this time he felt that the study of medicine must be postponed for a more extended course of preparation. In fact the resolution was virtually formed to devote himself to the life of a teacher. In the summer of 1842 he took up Greek by himself. All this time he received spirited encouragement from his father, although he had now passed beyond the limits of his father's education. He was working with Goodrich's *First Lessons*, when Rev. Davis W. Clark, then principal of Amenia Seminary (afterwards bishop) made his acquaintance and urged him to enter the Seminary, which he did September 6, 1842. The winter of 1842-43 was, nevertheless, spent in teaching a district school; though he pursued by himself the study of the *Æneid*, and of Sallust's *Catiline*. Astronomy, which he also studied, fired his imagination, and aroused latent perceptions which later became longings, and blossomed into beautiful fruition in his *World Life*.

1843. He rejoined his class in the spring of 1843, and stood with them the examinations in the studies of the year. During the winter of 1843-44 he was Assistant in the Seminary in the English department, in the spring taking Principal Clark's classes in Algebra. His studies this term took a remarkably wide range. Besides completing his preparation for a collegiate classical course, he finished the "teacher's course" in the seminary (including geology, mental philosophy, Paley's *Evidences of Christianity*, and natural theology), and received the diploma. He was vale dictorian of his class, and acted a part in a dramatic sketch (written by himself) entitled *The Reign of Terror*. There remain to this day, among the older, and especially among the later students at Amenia Seminary, traditions of the mathematical achieve-

ments of "that boy Winchell" during the last year of his study there.

1844. He was now prepared for college, but the difficulties that beset a youth who at that time aimed to acquire more than a common school education, if without means to meet the financial obligations, in any of the colleges of New England, can only be enumerated by those who have encountered them. His friends generally regarded the idea as chimerical. For a sustained aspiration to secure the benefits of such a course he here acknowledges himself indebted again to his father, who was educated at Phillips Academy, Andover, and to his uncle, Abraham Winchell, who had received a liberal education at Yale and Harvard. However, in September, 1844, he was matriculated as sophomore at Wesleyan University, Middletown, Conn. Here he encountered, with indignation, the first check in his educational ardor and success, in a rigorous "marking system," which at that time laid special stress on the literal reproduction of the words of the text-books. Like most of his class-mates—among whom were Edward Gayer Andrews (now bishop), Cornelius Cole (since congressman from California), Orange Judd (benefactor of his alma mater and long the distinguished agricultural editor), Joseph E. King (the well-known president of Fort Edward Institute)—he left the struggle for college honors to the very few who could cramp their natures to the narrow conditions of success. Heretofore he had always expected to win the first premium whenever a prize was offered for competition, but from college honors proffered under so narrow conditions he turned in disgust, and he always recollected with indignant condemnation the contrast between this discipline and that more generous and encouraging which he had experienced at Amenia Seminary, under Principal Clark and Joseph Cummings.

1845. The winter of 1844-45 he taught the village school at Winsted, Conn., and in 1845-46 he was assistant in Simmons' Classical School in his native town. He graduated with his class in 1847, being assigned the "honor" of the "modern classical oration." His theme was *The Dayspring of Italian Literature*. He then became teacher of natural science at Pennington Male Seminary, N. J., where he entered with irrepressible zeal and delight upon the study of the flora of the vicinity, by the aid of that admirable work, Darlington's *Flora Cestrica*. As the Morse electric

telegraph had just been put in operation between Baltimore and Washington he set himself to the task of producing, with his own hands, a working instrument, and though nothing beyond the fundamental principles had been made known to him, he succeeded perfectly. At a public exhibition and lecture he employed an alphabet of his own invention for transmitting intelligence to the farther corner of the hall. By popular request this lecture was repeated. Here also he gave a series of popular lectures on astronomy. During this year he devoted considerable attention to the study of Hebrew, under the instruction of principal Rev. S. M. Vail. The grammar used was that of Seixas; and as no copies were found in the market, he did not hesitate to make a manuscript copy for himself. Years afterward, his honored instructor, remembering the incident, presented him a printed copy.

1846-49. He now began to feel that the field of mathematics was less spacious and inviting to enterprise than that of modern science, and, declining the tutorship in mathematics tendered him by president Smith of Wesleyan University, and the offer of continued position at Pennington Seminary, he returned to the Seminary which had prepared him for college, where he accepted the chair of natural science. Here he gave his first public geological lectures. During 1849 he made a thorough exploration of the flora of the vicinity. With the small reflector of the institution he made some observations on solar spots, which were published in the New York *Tribune* for November 5, 1849. He began here also a series of meteorological observations which were reported to the New York regents, and published in the report for 1850. These and later observations are incorporated in the quarto volume on New York meteorology by Dr. Hough. He was married December 5, 1849, to Miss Julia F. Lines, of Utica, N. Y., who was the teacher of instrumental music at the Seminary.

1850. In 1850 he transmitted to the New York Board of Regents his first contribution to science, being a *Catalogue of plants found growing without cultivation in the vicinity of Amenia Seminary.** In July, 1850, he received from his alma mater the degree of *master of arts*, delivering on the occasion, by appointment, an oration on *Work*.

Having accepted the charge of an academy at Newbern, Greene

*Regent's Report. 1851, p. 256.

Co., Ala., he presented his botanical collection, numbering 1,000 plants mounted and labeled, to Amenia Seminary, and set out with his wife, October 5, 1850, for his destination in the then distant south.

Here, with the expectation of a larger field for observation and study, he found the "Academy" was located in the woods, in a small settlement, in the heart of the richest cotton lands in the state. It was materially unlike the situation which his imagination had pictured, but with the coöperation of his wife, and with the calculation of eclipses for an amusement, he entered upon the work of "building up" an institution—and not without some success, but the beginning was too small to suit him; and, having visited Eutaw, in the same county, for the purpose of purchasing some unused apparatus from an inanimate institution, he was induced to change his plans so far as to use the apparatus where it was, and attempt the resuscitation of the institution. Accordingly in the spring of 1851 he opened the "Mesopotamia Female Seminary," with a full corps of assistant teachers, and the usual paraphernalia, accompanied by the seductive announcements suited to the occasion and the latitude.

1851-52. There had always been an unrealized vision floating before his mind, of a course of scientific investigation. Here he entered with zest upon its execution. He fitted up a chemical laboratory, and, making some quantitative analyses, they were published in the Eutaw papers. He had already communicated to the *American Journal of Science and Arts* notes on the cold of January at Eutaw, Ala., and on the aurora borealis of September 29, 1851. He also opened correspondence with the Smithsonian Institution, and, kindly encouraged by Prof. S. F. Baird, assistant secretary, busied himself in making collections of plants, animals and fossils. During 1852 he transmitted to the Institution a large collection of plants and a considerable number of alcoholic specimens and preserved skins. Among the fishes was a new species, afterward described by Girard as Hybopsis winchelli. The Cretaceous formation of his vicinity interested him exceedingly and he made a faithful study of *Choctaw Bluff*, on the Black Warrior river, the results of which he communicated, through Prof. Baird, to the Cleveland meeting of the American Association for the Advancement of Science, in 1853. This was the first scientific description of the locality. Some of the

scientific papers published in the Eutaw journals in 1851-52 and 1853 were as follows: *Yellow Rain*, in which he first announced the nature of the sulphur-like substance appearing in little pools after a spring rain. By chemical analysis and by microscopic examination he proved it to be pollen from the pine regions of the Gulf border. Other topics were *Venomous Serpents; Analysis of Artesian Water; On the Use of green wood for Fuel; Examination of "Sandy Land" Soil; The Garpike.*

1853. In 1853 he had the satisfaction of witnessing the verification of his first geological opinion, ventured on an economical question. Artesian wells were extremely common throughout the region south of Eutaw, and it was much desired to have such a well in the village. He pronounced against its possibility, basing his judgment on the fact that the water-bearing stratum at the bottom of the Upper Cretaceous outcropped half a mile south of the village, while the Lower Cretaceous was composed chiefly of non-porous, argillaceous beds. The authorities, nevertheless, expended a thousand dollars in an unsuccessful experiment.

In July, 1853, he made the acquaintance, at the "Commencement" of the University of Alabama, of Prof. M. Tuomey, who proved a valuable friend. Here he saw for the first time those classical works for the southern geologist, Morton's *Synopsis of the Cretaceous system of the United States*, and Conrad's *Description of Tertiary Shells*. The former he transcribed for himself, and returned to Eutaw with new impulses toward investigation.

Successful management of a southern female institution of learning required, at that time, a large amount of personal solicitation, and much pandering to the southern love of display. To this he could not willingly stoop, even had he not determined to devote his vacations to scientific work. Partly for this reason, and partly for reasons for which he was not responsible, the seminary did not prove as prosperous as might be desired; and, having been elected president of the "Masonic University" at Selma, Ala., he sold out his affairs at Eutaw, and in July, 1853, entered a new field.

Armed with a "Prospectus," he started out, with a horse and buggy purchased for the purpose, to spread the claims of the University before the people of southern Alabama. The unannounced secret of the expedition, however, was the purpose to make it a *geological tour*. Not neglecting business interests to

any glaring extent he traveled by Cahaba, Prairie Bluff, Claiborne and the Zeuglodon locality in Macon county, as far as St. Stephens on the Tombigbee: and thence by Camden and Allenton, on the east side of the Alabama river, to Selma. No richer or more attractive region was ever open to the geologist. He stood where the veteran geologist Conrad had stood: he studied where the distinguished Morton had studied: he explored the hole where Dr. Koch had exhumed his *Hydrarchos*, and picked up the vertebræ of that serpent-like cetacean with his own hands. He gathered large quantities of Cretaceous and Tertiary fossils, and from Claiborne he shipped two barrels full to the Smithsonian Institution. The yellow fever was raging in Mobile, and had almost reached the districts which he visited; but a different fever was raging in his veins. At Claiborne he collected a quantity of undescribed fossils from the lowest beds of the Eocene, and fixed the northern limits of that formation twenty miles further north than had been mapped by Tuomey. For miles south of Selma he saw the fields overstrewn with *Hippurites* which the planters profanely burned into lime—as in Macon county they were using the precious vertebræ of Zeuglodon for "dog-irons" (andirons), stiles and gate-weights. His collections arrived at Selma in good condition, and he devoted the remainder of his vacation to assorting and determining them.

The collections sent to the Smithsonian Institution were highly appreciated by Prof. Baird, who wrote, December 26, 1853; "The collection of fishes is magnificent, nearly all undoubtedly new, six species of *Pomotis* alone, cannot give complete lists at present as the genera, even, of some are indeterminable. The whole is the richest collection we have ever received from the south. * * * Unless I much mistake you and your abilities it won't be many years before you will be called to a big professorship somewhere north or east. Mark my words for that"—Nine days after these words were penned he was elected to a chair in the University of Michigan.

It will illustrate how long the scientific investigator must wait, sometimes, after the seed is sown, before he can reap his harvest, to note that the geological specimens collected on this southern Alabama trip in 1853, and sent to the Smithsonian Institution, were investigated first in 1880, when Dr. C. A. White took them in hand, and among others described *Exogyra winchelli* from those sent from Prairie Bluff, on the Alabama river.*

*Proceedings U. S. Nat. Mus., 20 May, 1880, p. 294, pl. II, figs. 2 and 3, and pl. III, figs. 1 and 2; also Annual report of the Hayden Survey for 1876, pl. XIII, figs., 1 a, b, c, d. Compare the Annual Report of the Institution, 1853, pp. 51, 52, 57.

The "University" opened with encouraging prospects; but within a few days the yellow fever made its appearance in the city in a very malignant form. Half the population fled; the institution suddenly suspended operations. Two deaths occurred in the house where he, with wife and little daughter, was residing, but he and his family remained at their post. In November he received a letter (dated November 16) from president Tappan of the University of Michigan, announcing his election to the chair of "Physics and Civil Engineering" in that University. This position he quickly accepted, and the Masonic University was abandoned for a long vacation. His fossils were packed for the journey, during the long, silent and solemn days of visitation of the yellow fever.

Before leaving the state he paid another visit to Prof. Tuomey, taking with him a trunk full of fossils, from which Prof. Tuomey was permitted to retain all he chose. Among them were the undescribed Eocene fossils from Allenton. These remained in his hands awaiting attention until the federal army visited Tuscaloosa during the war, when, with the treasures gathered by Prof. Tuomey himself, they were devoted to destruction.

1854. He entered upon his duties at Ann Arbor, the 24th day of Jan., 1854, at the full professor's salary of $1,150 per year. His family who had visited in Utica, N. Y., joined him a month later.

The work of the chair devolved upon him a large amount of preparation. Instruments and apparatus were wanting, and he visited New York to make purchases. No good elementary text-books in civil engineering were in existence—a deficiency specially felt in the department of railroad surveying. He was obliged to compile and originate matter and methods; so that within a year or two he had wrought out the material for an original work on civil engineering. As a branch of physics he attended to the keeping of a complete series of meteorological observations which, while he held the chair, he reported to the Smithsonian Institution.

The State Agricultural College of Michigan, then lately established, had not yet been definitely located. The question of site had been referred by the Legislature to the executive committee of the State Agricultural Society. Seeing that they were about to decide, if they had not already decided, on a location in the

unsettled interior of the state, he drew up a communication on the subject, addressed to the executive committee, urging reasons for connecting it with the State University. The argument did not prevail, but the paper was published by the State Agricultural Society in its report for 1854.

During the summer vacation of 1854 he made some excursions in company with Profs. A. Sager and Charles Fox, for the purpose of making collections in natural history. A specimen of shell-marl collected was analyzed quantitatively, and the results published in the *Michigan Farmer*. He gave a good deal of study to the land and fresh-water-shells of the state, as well as to the reptiles and fishes.

1855. In the spring of 1855, he became enlisted in an effort to found a state Natural History Society, in connection with the State Teachers' Association, and read a paper,—published in the *Michigan Journal of Education* for March, 1855—*On the Pursuit of the Natural Sciences*. He also published a scheme of operations proposed. But interest in such subjects was at a low ebb, and the organization was so loose, and scattered, that this project never produced much fruit. During 1855, Prof. L. Agassiz' prospectus for a voluminous work on the *Natural History of the United States* was issued, and through personal request Prof. Agassiz appeals were addressed to the public by Prof. Winchell through the papers of Eutaw, Ala., and of Ann Arbor. In August he made a railroad survey from Ann Arbor toward Jonesville, as far as Manchester.

On the basis of an understanding reached, on his assuming the chair of "Physics and Civil Engineering," the University created, this year, the chair of "Geology, Zoology and Botany;" and to this chair Prof. Winchell was transferred. The meteorological instruments which he had purchased and used, impelled by his interest in natural physics, were surrendered regretfully to his successor. Prof. Winchell had indeed kept up a continuous series of observations ever since 1848, first at Amenia, under instructions from the New York Regents, then at Newbern, Eutaw and Selma on the blank forms of the Smithsonian Institution, and lastly at Ann Arbor. He still continued, however, with his own instruments, the full series excepting the barometric records. The habit established of regular observations of the weather is traceable even through the last weeks of his life, since his diary

nearly always records the morning temperature, and also makes mention of all extraordinary meteorological changes. His Ann Arbor observations were finally worked up under the auspices of the Smithsonian Institution, and also by himself in connection with the geological survey of the state.

1856. He read a paper, in 1856, before the State Teachers' Association, *On the importance of the Study of Natural History*, in which he advocated the introduction of these studies into the Union schools and the lower classes of the colleges. He read also papers before the American Association for the Advancement of Science, at Albany, N. Y., on the *Geology of Middle and Southern Alabama*, and *Statistics of some Artesian wells of Alabama.** Much attention was given also this year (1856) to microscopical studies; and a large number of drawings in colors were executed with the camera lucida.

1857. In the early part of 1857, he contributed, by invitation, a series of seven articles on *Popular Education*, under the signature of "Scholasticus," to the Detroit *Tribune*. In one of these, having animadverted on the "Prussian system," president Tappan put in a reply, extending over several numbers of the paper. It was stated at the time that the first articles emanated from the president of Kalamazoo College, Dr. Stone, and that president Tappan imagined himself replying to him.

At the request of Mr. B. F. Meek he made out a general table of the Cretaceous rocks of Alabama, which has entered permanently into the literature of the Cretaceous system.† He published this year also *A Guide to the Pronunciation of Scientific Terms*—a pamphlet intended for his own students, but which had quite a circulation among scientific men, until the edition was exhausted.

During the summer of 1857 he made a minute microscopic investigation of *Lumbriculus*, with colored drawings and descriptions. In the autumn and winter he drew up a detailed description of the osteology of *Menobranchus* (*Necturus*) lateralis. He opened in the autumn a class in comparative osteology, which was attended by about eighteen students from the Medical College, besides those from the Literary department. In subsequent years the professor of anatomy instituted a similar course for the medical students.

*See *Proceedings*, pp. 82 and 94.

†See Proc. Acad. Nat. Sci. Philadelphia, May, 1857, p. 126.

1858. During the winter of 1857-58 he delivered a series of public lectures, by request of the Young Men's Association of Ann Arbor, in the hall of the Union school. Except the public geological lectures of Dr. Douglass Houghton, in Detroit, this was the first presentation, before public audiences of the state, of the popular truths of geology. The final lecture, entitled, *Creation the work of one Intelligence, and not the Product of Physical Forces*, was published in pamphlet form by the Association. This was inspired, confessedly, by Agassiz' splendid *Essay on Classification*, in the sentiments of which he felt a profound sympathy. In May, 1858, he published, for the use of his students a *Synoptical view of the Succession of Organic Types*, which went through three editions. He carried through the Michigan *Journal of Education* a series of nine popular articles under the general heading *Leaves from the Book of Nature*. During the summer he visited Missouri, and held a quasi-connection with the geological survey then in progress under Prof. Swallow, sending to the Ann Arbor papers some account of what he saw.

1859. In January, 1859, he memorialized the State Legislature on the subject of a geological survey (House Document No. 29): and the survey having been ordered he was commissioned by Gov. Moses Wisner, as director. On the 16th of May he set out, with a camp-outfit and one assistant, A. D. White, for the personal examination of the southern portion of the Lower Peninsula. He served this year also as editor, and against his will, as publisher of the *Michigan Journal of Education*, to which he contributed numerous articles and criticisms—among them a popular solution of the celebrated "Pendulum Problem." As president of the State Teachers' Association he managed its interests, and delivered the annual address on *What Constitutes the Successful Teacher*. In October, having, during the season, studied the geological relations of the various brine springs of the state, he published, in one of the Grand Rapids papers, a general conclusion from which he never had occasion to recede. He discouraged the attempt to produce salt at Grand Rapids. His exploration of the Saginaw region enabled him to locate the salt formation at the depth of 650 feet beneath East Saginaw. This was before the first well was bored. Experiment revealed the existence of a supply of brine at 648 feet. As, during the same season, he had to oversee the erection of his new residence, costing about ten

thousand dollars, it is apparent that this was a year of unceasing activity.

1860. In 1860 the work of the survey called him to spend most of the summer season in camp around the lake shores. He was able to coördinate the salt wells at different points along the Saginaw river. The leisure of the year was occupied by paleontological investigations.

1861. His *Report of Progress of the Geological Survey*, an octavo volume of 339 pages, was published in August, 1861. In this he fully anticipated the vast development of the salt interest in the Saginaw valley. In consequence of the outbreak of the war the Legislature made no provision for the continuance of the survey, but the paleontological investigations were carried on privately through the year. As with all surveys the Michigan survey entailed on the director a burdensome correspondence relating to possible and projected economic measures in various parts of the state. One only need here be mentioned. To an applicant for information respecting the existence of gypsum in the vicinity of Tawas, he indicated a ridge near the lake shore, which he had inspected during the season's examinations (not the well-known outcrop by the water's edge further south) as a locality containing probably a large supply of gypsum. Some experimenters had already pronounced the locality barren; but his correspondent, taking a location for the price of an old gun, sold it, after the discovery of 18 feet of pure gypsum, for some thousands of dollars. On this spot has since been developed one of the finest gypsum quarries in the world.

1862-63. His special paleontological study was directed toward the series of strata which he had designated the "Marshall group," a Carboniferous assemblage which had been regarded by American geologists as the equivalent of the New York Chemung. He published a communication on these rocks in the Amer. Jour. Sci. [2], vol. XXXIII, p. 353, which contained his first descriptions of new species. Further descriptions were published in the Proceedings of the Acad. of Nat. Sci. Phil. for Sept., p. 405. He also published an article in Hunt's Merchants' magazine for September, on *The Salt Manufacture of the Saginaw Valley*. Researches in the Marshall group were continued through 1863, and the following articles were published: *On the Identification of the Catskill Red sandstone group with the Chemung* (Am.

Jour. Sci. [2], XXXV. 61): *Descriptions of fossils from the Yellow Sandstones lying beneath the Burlington limestone at Burlington, Iowa.* (Proc. Acad. Nat. Sci. Phil. Jan. 1863). He also published *Descriptions of elephantine molars in the Museum of the University of Michigan.* (Canadian Naturalist. October. 1863. p. 398.) He also investigated minutely the "Cherry slug." *Celandria cerasi*, and his report was published in the Proc. Bos. Soc. Nat. Hist., Feb. 1865.

1864. In 1864 he made a detailed study of the "Currant worm" microscopically and embryologically. The results were published in the Detroit *Free Press* and republished in the *American Journal of Science*, September, 1864. The following further papers were published this year. *Fossils from the Potsdam Sandstone of Wisconsin and Lake Superior* (Amer. Jour. Sci. [2] XXXVII. p. 226); *Notice of a Mastodon recently discovered in Michigan.* Ib. [2] XXXVIII. p. 223; *Description of a garpike supposed to be new* (Lepidosteus oculatus). (Proc. Acad. Nat. Sci. Philadelphia. Aug., 1864); *Geological map of Michigan: On the origin of the Prairies of the Mississippi valley* (Am. Jour. Sci. [2], XXXVIII, p. 332).

1865 In January, 1865, he delivered an address at Lansing, before the Executive Committee of the State Agricultural Society, on *The soils and subsoils of Michigan*, which was published by the Committee in pamphlet form. In this he insisted on the agricultural value of the "pine lands" of the state, and pointed out the existence of a large calcareous constituent in the sandy soils about Grand Traverse bay. He continued his investigation of the fossils of the "Marshall group," and published another series of descriptions of new species in the Proc. Acad. Nat. Sci. July, 1865. About this time his attention was much taken up with the phenomena of oil wells, and he was called to many and distant places for the purpose of making surveys. He visited and studied, in this way, all the oil-producing regions of the United States and Canada; and a large number of his reports were published by the proprietors in separate pamphlets. He wrote numerous articles also on these subjects for the public journals.

It was in February and March of 1865 that the germs of the malady which finally caused his death, were made apparent in an impairment of his general health and rheumatic pains. On the

invitation of Prof. James Hall, he visited Albany, carrying along with him a "trunkful" of fossils for mutual study and comparison in Prof. Hall's laboratory. Simultaneously with the commencement of preparations for this trip, according to his diary, rheumatic pains were perceived in various parts of the body. These were attributed to having taken a bad cold through exposure in the Museum, where he had to work without fire. Once only (February 14) while at Albany, he notes "continual fluttering and palpitation about the heart. Ears ring. Stomach impaired. No difficulty in drawing a long breath." Repairing to his father's home (Lakeville, Conn.) on February 16, he became much worse and passed through a severe siege of inflammatory rheumatism, under the faithful nursing of his mother, leaving there again for Albany on March 15, and reaching Ann Arbor, March 22. Although his rheumatic pains ceased gradually, the cardiac manifestations were kept up, and increased alarmingly. His diary for the next two or three years is burdened with references to the "thumping" and the "spasms" which he constantly experienced about the heart. He consulted Dr. Abram Sager soon after returning from Lakeville, and from his treatment he experienced some temporary relief. He carefully analyzed his own case, and the following may be taken as samples of many passages in his diary written when, at Lexington, Ky., he was inaugurating, under Regent Bowman, the courses in natural science, at Kentucky University. For years, and apparently until he was wholly incapacitated by the encroachment of the disease, he lived with the impending probability of sudden death constantly before him. After considering the question whether the peculiar sensations he felt might not be centered in the stomach instead of the heart, he writes:

Be that as it may the circumstances have been such that I have been led to think much about the probable shortening of my life. No one can think of death without some shrinking back. To go out of the world into the untried uncertainties which lie the other side of death is a serious business—to drop half-finished plans—to leave life's work but half completed—above all to leave a little destitute family—to break their hearts with bereavement—to leave my little daughters to the trials, griefs and exposures of an orphan life—poor, education and accomplishments not yet secured—Oh, this is trying. But it is after all for them rather than myself, that regret arises. As for me—the individual—I must die sometime, and the uncertainties of the future will be as great twenty years hence as now, and so far as regards nature's reluctance to

go down into non-existence. I have no desire to postpone the day. For the world's sake, for my name's sake, for surviving friends' sake, I had hoped to do more for humanity, more for science than I have, I seem to be now prepared to labor efficiently in the field of well-doing, I had hoped to complete my work on Natural Theology—my Geologic Ages and my Physiological Zoology. And then I am half prepared to monograph the horizon of the Waverly sandstone. Would that I might be spared to do that.

But there are real attractions on the other side of the dark river. I daily see, in imagination, my little angel trio standing hand in hand and looking longingly toward the shores of earth and wondering when papa will come. Oh, if I *could* feel the firm *assurance* that I should meet and know them there, I should cast every regret aside, and joyfully, joyfully, await the day. It may be that I can attain to this assurance. I understand that others have enjoyed it; and I pray God his spirit may guide me to the same acquisition. (26 Jan., 1867.) Again he writes (Feb. 11, '67): The other night as I was lying in bed and considering what could be the nature of the phenomenon, I concluded the most probable explanation is this: The spasm occurs during the time of contraction of the ventricles, as is shown by the suppression of the pulse, and by the failure of the sharp, "deep" sound caused by the closing of the mitral valves. It must be then that the mitral valves do not close when the ventricle contracts, and thus the blood from the left ventricle instead of being thrown into the aorta is forced back into the left auricle, meeting the blood just entering that auricle from the polmonary vein. This sudden and unusual influx of blood from both directions into the auricle produces a concussion and distension of that auricle and possibly an unusually spasmodic struggle of the whole heart. As the right auricle is situated near the centre of the thorax and contiguous to the stomach, the unusual movement which it suffers is felt by the stomach, and thus that organ seems illusorily to be the seat of the abnormal action as it is the seat of the sensation.

But in reference to this explanation it should be marked, 1. A regurgitation of the blood into the right auricle and a prevention by this means of the contents of the pulmonary vein from proceeding forwards would result in a momentary congestion of the lungs, which should be indicated by a sense of suffocation. 2. As I have never experienced symptoms of any real inflammatory action in the heart, or the region of the heart, and have never even suffered any pain except occasional wandering or shooting pains, which many times were seated in the muscular layers of the chest, I do not perceive it possible (aside from the existence of the spasms), that any such disease has existed in the structures of the heart as to cause an alteration in the constitution or efficiency of the valves. 3. There exists therefore room for some other explanation of these abnormal symptoms. At the same time irregular or intermittent action of the heart is caused frequently by the state of the nervous system; and at the same time these spasms and the pathological condition on which they depend, produce no perceptible influence upon my health.

On the whole, therefore, I am left in a state of uncertainty as to the *fact* of valvular disease.

Two things I have neglected to mention. 1. These sensations are about the same as are produced by a sudden shock--as when a window falls, or a door slams, or some person suddenly starts up before one. This would affiliate them to nervous affections. 2. Occasionally, lately, when lying quietly in bed, listening to the sound of the heart, I have fancied that the "deep" sound produced by the closing of the mitral valves is not as *sharp* as it used to be—but somewhat softened and prolonged. This is as I believe it should be if there is an imperfect closure of these valves, and some of the blood regurgitates into the auricle. But if this is the constant mode of action I am sure some impression should be made on my respiration, wh'ch I have not yet detected. I breathe as long as ever, and I am no more inclined to pant than ever.

In hypertrophy of the heart, the ventricles, from over nutrition, lose the requisite capacity; but so far as I can see this would result only in a more sluggish circulation of the blood, producing a sense of faintness and suffocation—instead of *irregularity* in the pulse.

1866. He applied himself, notwithstanding these solemn premonitions, and perhaps partly through the sense of the brevity of his remaining years, to his duties and to all his plans, with great diligence and effectiveness. In 1866 he published, in connection with Prof. Oliver Marcy, who supplied most of the specimens, "An enumeration of fossils in the Niagara limestone, collected at Chicago, Ill.," with two lithographic plates of illustrations drawn by himself. This contained descriptions of numerous new species. He made this year an economic survey of the *Grand Traverse region*, on which he published an octavo report of 82 pages, with a map. In an appendix of 20 pages were embraced descriptions of a considerable number of new species of fossils. This report first brought to notice the remarkable influence of lake Michigan upon the climate of the region, and the wonderful capacity of the latter for agricultural and horticultural production. The statements of the report aroused the incredulity of some of the state officials, and an independent survey was made which fully confirmed the report. He read before the American Association at Buffalo, a paper on the *Fruit-bearing belt of Michigan*, in which, as in the report, he brought statistics to exemplify the hitherto unexpected influence of lake Michigan in ameliorating the winter climate of the state of Michigan and prolonging the growing period. He read at the same meeting a paper on *Stromatoporidæ*, in which he described two remarkable new genera of fossils, and established a new family.

Having declined the chair of Geology, Zoology and Botany in Kentucky University, he was induced to accept a three-months winter engagement, and accordingly attended the Commencement in June, and delivered an inaugural address entitled *A plea for Science*, which the authorities published in pamphlet. In January, 1867, he entered upon the temporary engagement. He was unwilling to sever his connection with the University at Ann Arbor. He also served the Kentucky University in 1868, and Regent Bowman now pressed upon him unsuccessfully the presidency of the Agricultural college, which at that time conducted nearly all the scientific instruction of the University. About the same time he declined also the presidency of the University of Georgia.

1867. During the year 1867 he contributed to the *Northwestern Christian Advocate*, published at Chicago, by special request of the editor, Dr. T. M. Eddy, a series of twenty-two articles entitled *Christian Theology illustrated from Nature*. Dr. Eddy had witnessed his method with a so-called "Bible Class" at Ann Arbor, and desired some of the results spread before the readers of the *Advocate*. The fundamental conception of this series of articles was the harmony between the indications and doctrines of science and the central doctrines of the Christian religion. The scope of the discussion appears from the following analysis of the course:

INTRODUCTORY.

1. Nature and scope of the subject.
2. Nature of the two revelations.
3. Harmony of the two revelations.

THE EXISTENCE OF DEITY.

1. Human conception of Deity.
2. Direct evidences.

THE UNITY OF DEITY.

1. Harmony of creation in reference to space.
2. Harmony of creation in reference to time.
3. Harmony of creation in reference to plans.

DIVINE OMNISCIENCE AND OMNIPOTENCE.

DIVINE BENEVOLENCE.

1. Indications of divine benevolence.
2. Vindication of divine benevolence.

DIVINE TRUTH.

1. Untruth incompatible with divine benevolence.
2. Untruth is unnatural.

DIVINE JUSTICE.

1. Hangs on the proof of moral law.

2. The moral law written on the heart of man.
3. The moral law revealed in the material creation.

CREATION A DIVINE WORK, AND NOT THE RESULT OF DEVELOPMENT.

1. The inorganic history of creation.
2. The organic history.

THE DURATION OF MATERIAL EXISTENCE FINITE.

1. The present organism had a beginning.
2. The same hastening to an end.

THE ORDER OF CREATION.

1. The order indicated by Moses.
2. The order taught by science.

MAN THE LAST TERM OF THE ORGANIC SERIES.

THE ORIGIN OF OUR RACE IN THE ORIENT.

THE NOACHIAN DELUGE.

1. Uninspired evidences of its occurrence.
2. The deluge not universal.

CORPOREAL DEATH NOT THE CONSEQUENCE OF SIN.

SIN, PUNISHMENT AND FORGIVENESS.

THE EXISTENCE OF THE SOUL.

1. Innate convictions.
2. Mind in nature.
3. Correlative of the brain.

FUTURE EXISTENCE.

1. Innate beliefs.
2. The indestructibility of spirit.
3. The incompleteness of earthly existence.
4. The attributes of Deity pledge future existence.

FUTURE PROGRESSION.

AUTHENTICITY OF WRITTEN REVELATION.

INSPIRATION OF THE SACRED SCRIPTURES.

THE NECESSITY OF FAITH.

CONCLUSION.

These articles attracted wide-spread attention in the circle of intelligent readers to whom they were addressed, and they received many testimonials to their value. It was critically pointed out that their method was much broader than had commonly been introduced into natural theology. He was solicited to put these contributions into book form, and especially by the late Dr. B. F. Cocker, his beloved colleague at Ann Arbor; but the treatment fell so far short of the degree of thoroughness which seemed to him befitting the theme that he resisted all solicitation to republish, entertaining the belief that within a year or two he would be able to offer the public a more adequate discussion. He began at once a re-cast of his argument, but the more he studied the more he became convinced that the apodictic and therefore the

satisfactory proof of the being of God must be rooted in *a priori* evidence. Illustrations from nature are all useful on the antecedent proof that there is any reality whose being and attributes are illustrated. With such maturing views he wrote one or two hundred pages again and yet again, during the succeeding years: but a few months lapse of time so changed his conception of the most appropriate treatment that all which had been written was rejected. Out of some portions several articles were prepared for the Methodist Quarterly Review (April, 1873, and Jan., 1874), viz: *The unity of the physical world*, and *Religious ideas among barbarous tribes* (Jan., 1875). Some of his maturer views were also embodied in a review of Cocker's *Christianity and Greek Philosophy* (July, 1872).

1868. During 1868 circumstances directed his attention particularly to the popularization of science. He had written, in 1858, a series of popular geological articles for the *Michigan Journal of Education*, and later had written a similar series for the *Ladies' Repository*, of Cincinnati, under the general title *Voices from Nature*, and at the special request of the editor, Rev. Dr. D. W. Clark. These Dr. Clark had suggested to him to have published in book form, under the title of *The Geologic Ages*, but he was not satisfied with the treatment he had there given the subject, and resisted Dr. Clark's flattering solicitation.

He was beset, however, on every side, by requests for popular articles, most of which he had to refuse. However, from his pen appeared three articles in the "University Magazine," four in the "College Courant," and three in the "Western Monthly." He conceived also an extension of the project of popular lectures, in which the grand conclusions of the sciences should be set forth in more glowing and popular style than till then had been customary with scientific lecturers of good scientific standing. His experience in composition had convinced him that the public possessed an appetite for solid information, though they demanded it well spiced. Contrary, therefore, to the precedents of his elders and the strong conservative judgment of the leaders in science, he boldly took the risk of an attempt to present science in a popular garb. The result was about what he had anticipated. While fair audiences of deeply interested people attended his lectures, there were crowds who would be attracted only by a great and popular name or a public entertainment which, either in its subject

matter or its author, amounted essentially to a mere amusement or a spectacle. Though never devoting any portion of his time expressly to the *business* of lecturing, he gave annually twenty, thirty, or more such lectures and his voice was heard in nearly all the cities of the West and Northwest where literary societies or lecture courses are maintained.

In October, 1875, when in Boston, he met Prof. R. A. Proctor, and attended two of the lectures in the course which he was then delivering before the Lowell Institute. In conversation he remarked to Prof. Proctor the difference in the methods pursued by Proctor and himself to gain the attention of popular audiences. Proctor took a special theme of limited scope, and brought out all the details and personal and biographical history connected with it. This appeared to him the method of the story-teller. Winchell took a grand chapter of cosmical history, and presented synthetically the grand conclusions attained by science, ranging them in logical rather than chronological order—appealing to the understanding of his auditors for interest, and to their imagination for illustrative pictures. In later years it was evident that Proctor's lectures more and more adopted Winchell's method, at the same time also approximating more closely to the same *themes*. During his American tour of 1879-80 he made his lecture entitled "The Life of a World" the staple entertainment for the public. His other lectures, "The Moon," "Death of Worlds," were simply amplified chapters in a general cosmic history.

Dr. Winchell was perhaps the very first scientist in America who descended before popular audiences, from that high-caste and stately, but dry and unpopular, style in which the older scientists had thought it fit to cloak the dignity of science. Certainly no one but the elder Agassiz had previously attempted a true popularization of science, but his lectures were never heard by the plain people in the smaller cities throughout the country. He simplified zoological themes, rather than popularized them, and lifted up his voice only in New York, Brooklyn, Boston, Mobile, San Francisco, or other large cities where the select appreciators of science were numerous enough to constitute an audience. Since 1868 the popular platform has been occupied by a considerable number of lecturers of scientific repute, among whom may be named Waterhouse Hawkins, Richard A. Proctor and Edward S.

Morse. But two of these have relied largely for popular interest on what is really but some trick of black-board sketching. In Great Britain have arisen also the illustrious names of Tyndall, Huxley, Lockyer and others.

This lecturing did not divert him but casually from his permanent plans of scientific work. In 1869 he prosecuted his studies on the "Marshall group;" some of his contributions were included in other state geological reports, and the scientific journals. His most voluminous publication on the subject appeared in two numbers of the Proceedings of the American Philosophical Society. This presents a general resumé of discussions bearing on the rocks in question, a study of their equivalency in the various western states and the lithological and paleontological evidences of the unity and distinctness of the group, and its proper position in the Carboniferous system.

1869. On the re-organization of the geological survey of the state, governor Baldwin re-appointed him director, and he was enabled to resume the work which had been suspended by the intervention of the war of the rebellion. Nine years had elapsed, and he had learned much, in his private travels for economic surveys at various localities, of the rock-structure and physical features of the state. He assumed for himself the personal investigation of the Lower Peninsula, and committed to major T. B. Brooks the study of the Marquette Iron region. As director he drew up a plan of operations which major Brooks pursued to the completion of his work, some four years afterwards.

1870. For several years he employed every opportunity to collect data relative to the Winchell name in America, and he put his information in systematic shape in a volume, which appeared in February, 1870, entitled *Genealogy of the Family of Winchell*, an octavo volume of 272 pages, containing names of about 3,000 of his relatives. In March of the same year appeared "Sketches of Creation," a purely popular work embodying some of the grander views of geology which he had previously presented either in print or from the public platform. "Some portions of it indeed surpass the requirements of a popular style and become sophomoric and stilted." So he himself criticised it. It presented accurately, however, some of the accepted doctrines of science, and contained many thoughts and speculations original with the author. His picture of the primeval condition of the

world, and especially of the stormy period, antedated (in 1858 in the "Michigan Journal of Education") the publication of the similar pictures of Figuier; and his speculations concerning the wastage of the land, the final refrigeration of the earth, and the sun, and the inevitable running down of the machinery of the solar system, were entirely independent: though it later appeared that Mayer had preceded him in reference to the doctrine of solar cooling, and Sir William Thompson had already announced the germ of his doctrine of the "dissipation of energy."

The popular character of the work tempted several ignorant reviewers to speak of it as a compilation, and as something similar to the attempts of Hitchcock and Hugh Miller. The *Nation* received it with that affectation of superior wisdom, and that pompous superciliousness which have since been the recognized characteristics of that conceited journal. With these exceptions the work was received with a universal and cordial welcome. From his numerous scrap-books the following, from the New York *Independent*, is selected as a sample of the judgment of the best critics.

But setting aside the engraver's help toward the rich attractions of this volume, and confining ourselves simply to the author's manipulation of words, we should call this a very *picturesque* volume. Dr. Winchell is a learned professor of the sciences of geology, zoology and botany; but more than that he is a singular master of the art of telling about these sciences. His mind is filled with the poetry of science: he brings his heart and his imagination into the field as allies of his analytic faculties; and his essays in the popularization of science are really extraordinary specimens of word-painting. Like Waterhouse Hawkins, Dr. Winchell is a popular orator of the facts of natural science: and like Hugh Miller, Tyndall, Huxley, Agassiz, he is also the graphic rhetorician of those facts. If any one has supposed that geology is a dry, dull science, he can be cured effectually by the perusal of the *Sketches of Creation*. It clothes the dry bones of an august science with the living flesh and splendid vestments of poetry. Its rehearsal of the tremendous story of the physical universe is a superb prose epic.

In similar strain wrote the *New York Evening Post*, the *Chicago Post*, and nearly every other reviewer. The remarkable sale of the work combined with these commendations and many friendly letters, demonstrated that the author had reached the very audience for whom he wrote. The publishers accounted to the author for 4,181 copies sold within the first six months, and they testified subsequently that no scientific work ever published in America

had found so large a sale as the *Sketches of Creation*. A large demand has continued to the present date.

Almost simultaneously appeared his *Geological Chart*, intended for the class-room of the college and the High School.

1871. But his principal activity was demanded by the duties of the geological survey. In the latter part of 1870 he drew up a preliminary cast of a report of progress, and in Jan., 1871, it was submitted to the Legislature. It was printed at once in pamphlet. This did not attempt to embody results, but set forth the plan of operations and the scope of the work contemplated, producing estimates of final cost, with a degree of unreserve more candid than judicious. The greater part of an octavo volume was substantially ready for the press. But a hostile influence had insinuated itself into the Legislature. The Senate very promptly passed a bill making appropriations for publication; but the House was now under the manipulation of one S W. Hill, from the Upper Peninsula, who had taken offense at the employment of Prof. R. Pumpelly, instead of himself or some other resident of the district, to prosecute the survey of the copper region. Mr. Hill had been a subordinate employe of the survey under Foster and Whitney, and was known as an exploring miner or "expert" in the Northern Peninsula. As director, Prof. Winchell had made a preliminary arrangement with —— Forster, who was well versed in the facts connected with the geological developments of the region, but Gov. Baldwin objected, because Forster was already one of the commissioners of the Sault canal. Hill was utterly incompetent and out of the question, though both ambitious and unscrupulous. Prof. Pumpelly was well known, even then, as a student of such ore-deposits, and was the most suitable man. But Hill notwithstanding his assuring and friendly letters, conceived an implacable hostility to the director and to the survey, and secured his election to the Lower House with the proclamation that he would kill the survey. So by the most industrious, insidious and unscrupulous misrepresentations and perversions of facts, he created a strong adverse sentiment. In this he was aided by Dr. Manly Miles, then residing in Lansing, who ten years before had so mismanaged the Zoological department of the survey then in progress, that the director got rid of him by having the Zoological department abolished. Between the two sufficient influence was exerted to induce a majority of

the house to withhold appropriations for publication, and to this day the materials that were gathered under his administration in the Lower Peninsula for two seasons of field work largely remain unpublished. They fill numerous large record volumes of manuscript.

Meantime governor Baldwin, whose authority had compelled him to take the step which roused such deadly hostility, neither assumed the responsibility, nor justified the director in any official way, and the latter was restrained by official etiquette from shifting upon another the responsibility for his official acts. The whole Geological Board had but recently fully endorsed all the plans and operations of the survey: but they had not the virtue to defend what had been done with their open and individual approval. So, on the failure, or impending failure, of the appropriation, the director sent in his resignation, glad enough to be relieved from what appeared to be the tyranny of an ignorant and capricious Legislature. "A Remarkable Maori Manuscript," published in *Sparks from a Geologist's Hammer*, is a parody of this episode.

At the dedication of "Orange Judd Hall of Science," at the Wesleyan University, at Middletown, Ct., he delivered an address on *Scientific Education*. The institution was his alma mater, and its benefactor was his classmate. This address assumed bold and forward ground, and was published in pamphlet. The Boston *Advertiser* said: "It will be likely to attract much attention among all who are interested in the 'modern protest,' since it takes decided and strong grounds in favor of the new education, boldly advocating its advantages, not only for special training, but for that liberal culture and discipline of the mental faculties and the character, which, it is generally supposed, can be obtained only from the classics. It will take rank with the most thorough and able arguments yet presented on this side of the discussion." On this occasion he received from his alma mater the degree of Doctor of Laws.

His recent experience with the versatile lower house of the Legislature of Michigan brought sharp confirmation of a conviction, which he had already entertained and expressed, as to the unrestricted extension of the elective franchise to the ignorant citizen. The progress of the institutions of American civilization he considered endangered by thus putting them into the hands of

ignorant and too often unappreciative trustees. Such views were embraced in a lecture entitled *Kakistocracy, or Too Much Popular Government.* This was first delivered at Mattoon, Ill., Dec. 4, 1871. It appeared in the *Mattoon Journal* of Jan. 6, 1872. The lecture, as may well be imagined, created considerable excitement, as it went point blank against the short-sighted, material selfishness of the rabble, and the aspirations of the self-seeking demagogues who lead them. The lecture was, however, rewritten and delivered, March 13, before the "Jeffersonian Society" of the Law Department of the University of Michigan.

1872. A series of articles adapted to the *Sunday School Journal* were published in that periodical in 1872, and subsequently were amplified into a volume entitled *Reconciliation of Science and Religion.* He was this year vice-president of the American Association for the Advancement of Science; and poet for the twenty-fifth anniversary of his college class. On the latter occasion he delivered a very touching and melancholy, though perhaps appropriate, poem, which is one of the rare occasions on which he allowed the outer world, which knew him chiefly by his scientific contributions, to have a glimpse of the inmost recesses of his heart. Here he poured out his grief *in an impersonal way, in beautifully flowing metre—of which there are also numerous other examples scattered through his diary and his record books.

1873. He experienced a severe trial, on leaving, in 1873, the University of Michigan, and accepting the responsible position of chancellor of Syracuse University. The step was long debated, and he could scarcely bring himself to abandon all the ties which bound him to Ann Arbor and the State of Michigan. He had heretofore firmly resisted the personal solicitations of various committees to enter upon what they, with the world in general, regarded as "a wider field." But now the representations of the authorities of Syracuse University were to the effect that the institution was in rapid progress of endowment, and had already a productive capital of $650,000, and that, as it was his scientific reputation which had attracted them to him, they wished him not to discontinue his relation to the scientific world. His salary would be more than double what he was receiving from the University of Michigan, and he would not have to be worried with the financial affairs of the endowment, since there was a salaried

*He had lost three of his children by early death.

officer to look after that. He was very cordially received and introduced by bishop Peck and Drs. Reid and Bristol. His inaugural address was a broad and searching discussion of *The Modern University.*

A portion of the material intended for the report of the Geological Survey of Michigan was condensed for Walling's *Atlas of Michigan*, embracing articles on the geology, topography and climate of the state. These memoirs subsequently were collected in a volume of 121 pages, accompanied by topographical, geological and isothermal charts—six in all. Resulting from the same study he contributed to the *Amer. Jour. Sci.*, July, 1873, a paper on *The Diagonal System in the Physical Features of Michigan.*

As soon as he had opportunity to learn the financial condition of the University, he discovered that it was not what he had been led to suppose, and that the financial stringency of the times (1873) bore heavily on even what there was of a firm foundation for future expectation. Notes which had been given on the opening of the institution were met with disheartening non-payment, and on others the productive interest was eaten up by second-hand men and bankers who had advanced money on them and held the short time notes of the University. However, he kept up good courage, outwardly, to the end of the scholastic year, and in July he sailed for Europe, intending there to leave his family for a short sojourn while his eldest living daughter should enjoy the opportunity and advantages of musical instruction by the best foreign masters. He returned himself to Syracuse on the opening of the new scholastic year.

He delivered a course of four geological lectures during the autumn at Cooper Institute, New York, and two on evolution before the "Drew Theological Seminary," the latter, in April (1874), appearing as a small volume from the press of Harper Bros. A reviewer of this work in the *New York Tribune*, in connection with that of Dr. Hodge, on a similar subject, said:

> The second writer whom we have named, the Chancellor of Syracuse University, in this state, is a much younger man, less addicted to theology than to natural science, not known to so large a public, but held in the highest esteem in scientific and literary circles, the author of several works of excellent fame in his favorite department of study, with a freshness and earnestness of thought which give promise of future achievements of high import, and with a mental courage that does not shrink from the sacrifice of custom and tradition for loyalty to truth.

The purpose of the work was neither to defend nor oppose the doctrine of evolution, but to offer expositions and discriminations. The fact of an evolutionary method in nature he unreservedly maintained, and held it to be a proof of intelligence. Whether the evolution of events is effected by a method of material continuity, he deemed the only question at issue. He held that in the inorganic world the reality of this method must be acknowledged. Whether a material continuity runs through the series of organic forms, is the residual question, to which all scientific controversy has to be narrowed. He proceeded to indicate the general evidences adduced by evolutionists in support of the affirmative, and then brought forward a series of difficulties, most of which, however, were regarded as applying rather to Darwinism than to the general doctrine of continuity. Supposing this doctrine inductively established as representing a fact in nature, it still remained to ascertain the methods and instrumentalities through which the organic continuity is maintained. This is the field of the theories—of which Darwinism is one. Finally, having agreed on the nature of the physiological processes involved, it is necessary still to ascertain the *origin* of those processes, and of the forces which sustain and guide them—that is, the philosophic question of ultimate causation remains. From such grounds he maintained that no form of evolution-theory can be set down as essentially atheistic.

The fourth visitation of death in his dearly loved family was announced to him by cable-dispatch shortly before Christmas, 1873, when he was about to ascend the platform to deliver a public lecture in St. Paul, Minn. Diphtheria had smitten his youngest daughter at Berlin. With masterful self-control he commanded his grief to be silent and his thoughts to be on his evening topic, and he gave his lecture as announced. To one who knew the tenderness of his heart and fond doting which he lavished on his children, this abstraction of himself, almost from himself, for an hour and a half, with such a shock fresh on his consciousness, revealed the doubleness of his existence. He lived a public life of activity which was wonderful for its accomplishments, but he had a domestic and personal life which, in its recorded memories and mementoes, was almost equally voluminous. The drapery of a private grief was hung continually on his heart, but he carried in his hand, as his only public and outward symbol of action, a

banner on which was written "Excelsior." He devoted many, but separate, hours to service under each. Without concluding his western engagements to lecture, he returned to Syracuse and awaited the arrival of the cherished remains. At length, on Feb. 1, 1874, they were given their final resting place at Ann Arbor, by the side of two sisters and a brother.

1874–76. Owing to the desire on the part of the University authorities that he should now take part in public efforts to augment the endowment, and to the serious curtailment which he had already suffered in his scientific work through the incumbency of the presidency, contrary to inducements held out to him on his acceptance of it, he notified the trustees, in March, of his intended resignation, and in June he unconditionally retired. For the duties of solicitor of money he had no qualification. Between paleontologist and financial agent there was a gap so broad that he had never contemplated crossing it. In July, 1874, he again visited Europe, and returned with his family in December, entering now in the same university upon the chair of geology, which the trustees created and urged him to accept.

Full of zeal for the development of the department which he had assumed in the Syracuse University, he prepared and published, at his own expense, an extended *syllabus* of a proposed course of geological lectures, which should possess interest for the general public. He found it difficult, almost impossible, under the financial straits of the institution, to equip and maintain laboratories which corresponded with his ideas of the professorship of geology. It became evident that his position was not one in which a zealous and competent professor of science could build up either a reputation or a successful department. While he was meditating a complete severance of his relations he was called upon by bishop McTyeire, of the M. E. Church South, who urged upon him the chair of geology, zoology and botany in the nascent Vanderbilt University, at Nashville, Tenn. Under the precarious condition, however, of the endowment of that institution at that time, he declined the position, although he subsequently accepted a three month's engagement. In June, 1875, he presented his resignation at Syracuse, but consented to retain a partial engagement of two months.

On a basis of observations made in July, 1875, on the line of the Grand Rapids and Indiana railroad, he presented to the

Detroit meeting of the American Association for the Advancement of Science a communication entitled *Rectification of the Geological Map of Michigan.*

In the autumn he wrote and delivered, before the Boston Theological School six lectures on the Relations of Religion to Science and Philosophy. These were afterward embodied in a volume. In January, 1876, he opened a "School of Geology" at Syracuse University. This had been announced by prospectus since August. For this enterprise he bore most of the financial expense himself. He wished to make the school of geology a permanent feature of the institution. The attendance, however, was small, the aid he had expected from the university was not rendered, the institution was located far from the city, cutting off some who would have joined had it been accessible, and his tenure of the position was feeble: for these reasons the second year's engagement here was devoted chiefly to university students. At Nashville, the first year, he devoted three months to lectures and instruction in geology and zoology. He delivered the commencement address at the "State Female College" at Memphis, and the Athenæum, Columbia, Tenn. He also gave the address before the literary societies of Vanderbilt University. His theme in this address was *The Worth of Culture.* In that before the female college it was *The Beautiful.**

At Vanderbilt University he was treated with very marked courtesy and hospitality by all connected with the institution, and he was importuned by some of the officers, seconding the requests of bishop McTyeire, to consent to a full connection and a permanent residence, but his first experience in the university convinced him that the old theology had too firm a grip on the institution to render it hospitable toward modern science, and, mentally, he shrank from any more intimate contact with the theological relics of the dark ages. During his first sojourn at Nashville he completed the preparation of a volume on the relations of science and religion, which he sent to his publishers, Harper and Brothers. He also reviewed Dr. B. F. Cocker's *Theistic Conception of the World* (*Meth. Quart. Review*, July, 1876.) During the same period he made a scientific investigation of the *Cephalopoda*, belonging to the museum of the university, bringing to light several new species, and interesting features in old ones. Most

* Reproduced in *Sparks From a Geologist's Hammer.*

of these shells were from the Silurian of Tennessee. For lack of books and specimens for comparison he did not bring the results to such a state of completion as to render it proper to offer them for publication—hoping for future opportunities of study.

Returning to Syracuse, he devoted a month to the study of fossils from Chautauqua county, regarded by him as belonging to the same age as the "Marshall group." He had collected these on occasion of a visit to the Chautauqua Lake Encampment, where he delivered two or three popular lectures. This study was made the basis of a communication to the American Association at its Buffalo meeting, where he also presented the results of a study of *Endoceras*. He participated in a "Normal Institute" of the college of fine arts, delivering four lectures, and taking some part also in the field work.

He was now importuned by the editors of the *Christian Union* and the *Methodist Quarterly Review*, for communications on the subject of evolution, with particular reference to Huxley's recent lectures in New York. * He also visited Prof. O. C. Marsh, at New Haven, for the purpose of examining the specimens which had served as the basis of his later announcements. He wrote a large manuscript of about twenty thousand words, on "Evolution," designed primarily for the *Methodist Quarterly Review*, but the matter remains unused. Early in December, 1876, he removed his family to Ann Arbor, where he had retained his old home, being convinced that it would never become desirable to settle permanently in Syracuse.

1877. After a short term of service at Syracuse, in the months of January and February, 1877, during which he wrote a series of eight lectures on the scientific evidences sustaining the doctrine of evolution, covering the ground of its philosophic and theological consequences, and constituting a full monograph, and drew up an extended syllabus of lithology for the use of students, he again transferred the scene of his labors to Nashville, Tenn., where, with a series of lectures on geology and zoology, he organized a biological laboratory which was very popular with the students, and, under the optional or "school" system prevailing there, became quite crowded with persons unprepared by previous study and discipline. During this term he instituted an elaborate series of experiments upon living germs in the atmosphere, employing

* See *Christian Union*, Oct. 11, 1876, and *Meth. Quar. Rev.*, April, 1877.

the general methods of Tyndall. He came to the conclusion that when an infusion is completely sterilized and exposed only to sterilized air, no living organisms come into existence, even after the lapse of eight months, and, hence, that the so-called "spontaneous generation," or archægenesis is purely imaginary.

In 1877 was published a work entitled *Reconciliation of Science and Religion*. It embodied the six lectures delivered before the Boston Theological School, the two Baccalaureate addresses delivered at Syracuse, a paper entitled *Some Thoughts on Causality*, read before the Albany Institute, reviews of Dr. B. F. Cocker's two works, and the series of articles written for the *Sunday School Journal*. Nothing, in reality, was written specially for this volume, but everything had been prepared originally for an ulterior use, and every investigation was tributary to the great work which was resting dormant, but not forgotten, on his hands. It was a volume of "chips," as Max Muller would say; but some of the investigations were fuller than he could with propriety introduce into his main work, and he thought the publication of them due both to himself and to those who had been awaiting the results of his studies. Toward the close of an extended review of this work the critic of the *New York Tribune* said:

Without dwelling on other points discussed in this suggestive volume, we may venture to thank the author for an original and fruitful contribution to the questions which now engage the attention of so many of the profoundest thinkers of the day. This work is of a critical character, commenting freely on opinions and systems which have found a place in the history of philosophy; but it also presents the mature fruits of independent research and reflection. It betrays an intimate acquaintance with the development of thought in the best ages of scientific culture; but its principles are not the result of sympathy and adoption. The author acknowledges no man as his master; he admits no conclusions which he has not made his own by processes of thought and study similar to those in which they had their origin. The materials which he has obtained by scholarly labors, have been thoroughly fused in his own mind, and are reproduced in forms which bear its image and superscription. He is evidently embarrassed by the fertility of his conceptions. * * * The rare intellectual fairness which marks the volume is a feature of no less interest than the philosophical ability with which its discussions are conducted.

The Northern Christian Advocate stated:

We do not remember ever to have read a work which more impressed us. * * * It is a book for the believer and the doubter, for the student and the theologian. It is both comforting and disquieting. It solves

some difficult problems, and in this time of perplexity and mental conflict, every helpful utterance should be heeded. * * * It is not a belligerent book, but a thoughtful and explanatory one. It is a reconciler. * * * As to the matter of style, it is gracefully but strongly written. Exhibiting a wide acquaintance with ancient and modern forms of thought it is never dry or obscure. * * * The book is full of thought. It is a noble contribution to American literature.

The Popular Science Monthly (Aug., 1877) stated:

The question of the relations of Science and Religion receives a new treatment in this interesting volume. * * *

Speaking of the author's theory of cyclic actions and reactions between intellect and the religious faculties, the reviewer says:

This is an original and ingenious conception, by which Dr. Winchell is enabled to group and arrange the elements of his discussion, historic, religious, philosophic and scientific, in a very instructive manner for his purpose, and on this account the exposition is certain to be read by general students with interest and profit. Dr. Winchell's work will do special service among religious leaders by making the whole discussion, as we might say, a piece of natural history: that is, he treats it in both its aspects, as a part of the method and phenomena of nature. While holding to the inspiration of the bible and the supernatural claims of christianity, as matters of his own special faith, he nevertheless holds to the validity of the universal religious sentiment in man, and which is as much a subject of rational inductive inquiry as are the physical sciences themselves. We can hardly overrate the gain thus secured, by bringing the whole inquiry into the scientific sphere, and conducting it in the broad judicial spirit which genuine science always imposes.

Such approving words from representatives of both the parties which the work attempts to "reconcile" affords some indication that the attempt was not a failure.

During his sojourn at Nashville in 1877, he made an extensive collection of the fishes of the Cumberland river, a series of which, transmitted to the Smithsonian Institution, was found to embrace a new species, *Arlina atripinnis*. (See Bulletin No. 10, U. S. Nat. Mus., p. 10.) He collected also a complete series of the Unionidæ of the river. These and the fishes remain in the museum of the university. He secured the youngest specimens ever seen of the garpike of the Cumberland. These ranged in length down to three-quarters of an inch.

He returned to Ann Arbor full of the purpose to resume work on the undertaking so long contemplated, but having to make a journey to Syracuse and Albany, for the purpose of reading a paper (on *University Control*) before the "University Convocation,"

and on his return to prepare a carefully studied article on ***Prehistoric Man*** (including the question of *Preadamites*) for McClintock and Strong's *Cyclopedia*, it was late in the summer before he could sit down to the work. Still again, in a few days, he was interrupted to deliver lectures before the "Convention" at Clear Lake, Iowa.

After a careful examination of his former work he was convinced that the only satisfactory course to pursue, though on an enterprise already three times begun, was to begin again. The whole scheme of the work was cast anew; and before his departure for Syracuse, in the latter part of November, he had completed about 121,500 words.

At Syracuse, where his term of service began, on Nov. 21, his popular course of weekly lectures consisted of seven, written on the primitive history of "world-life." In the course of these lectures he advanced the original idea that the meteoric matters now known to be disseminated through space, may be adequate to cause, by their resistance, the anomalous acceleration observed in the orbital motions of the satellites of Mars—especially the inner one. The same conception was subsequently advanced by Prof. Doolittle, of Washington, and Dr. Winchell made reclamation through the *New York Tribune*, inasmuch as his own views had been announced in public lectures in Syracuse, Cleveland and Lebanon, O., and Richmond, Ill., and had also been reported in the daily papers of Syracuse. Prof. Doolittle very cheerfully acknowledged Prof. Winchell's priority.

The study of Preadamites had deeply interested him, and had produced a pretty firm conviction that men existed upon the earth before the biblical Adam. He had planned, therefore, to deliver a lecture at Syracuse, upon the subject of *Adamites and Preadamites*. This lecture he was requested urgently to deliver in one of the churches, and he did so. At the request of the clergymen present the lecture appeared in full in one of the next morning's papers. In a day or two the author was called upon by Rev. Dr. Warren, editor of the *Northern Christian Advocate*, with a request to write half a dozen articles on the same subject, for his paper. To this request he acceded, but had not proceeded beyond No. 3 before Dr. Warren desired him to extend the series to eight, and before this limit was reached the editor wished the series extended to ten. At the request of the assistant editor, J. T. Roberts,

permission was given by the author to print the whole in pamphlet form. Hence the "orthodox" bruit which followed respecting his "unsoundness."

1878. On returning, February, 1878, to Vanderbilt University, he was received with the same politeness and cordiality. Though his work was, in general, the same as before, he occupied some of his leisure hours in constructing some pieces of microscopic apparatus. During the summer he also constructed a small working steam-engine of one-fifth horse power. Before leaving Nashville he had also completed a survey of the sanitary geology of the city, and drawn up a report to the Board of Health, which was embodied in the report of the Board for that year, and also was printed by the Board in pamphlet form. In making the survey he ran two intersecting lines of levels between the extreme limits of the city, a work in which his experience as professor of civil engineering twenty-three years previously, availed him.

On the morning of the 27th of May, an hour before the appointed time for a public address which he had been solicited to deliver, as one of the exercises of commencement week, he met bishop McTyeire casually, and the latter then proceeded to comment on the influence which would be exerted against the interests of the university by the professor's heterodox position in reference to Preadamites and evolution. He endeavored to show the bishop the unreasonableness of objections to an opinion founded on scientific evidence, and not held in conflict with fundamental religious beliefs; but the latter would not see the subject in that light, and asked him to relieve the university of an embarrassment by declining a reappointment. This he indignantly refused to do on any such grounds as alleged. He went almost directly to the public audience, assembled in the chapel, and delivered an extemporaneous address on *Man in the Light of Geology*. He felt that the bishop had been extremely inconsiderate in bringing before him so distracting a subject, on the very hour appointed for his address, but with that self control which had marked his action in various other trying occasions, he centered his mind on the topic before him, and was subsequently led to believe that the bishop's course had acted simply as a stimulus, enabling him to outdo himself in eloquence and perspicacity. The address, at all events, was praised on every hand.

The next morning, May 28, 1878, he took a final leave of the

university and of Nashville, and the same day the Board of Trust abolished his chair. Bishop McTyeire, in transmitting notice of this action, employed terms expressive of kind feeling, appreciation and even of regret. It was evidently the intention of the authorities of the university that this should be a case of decapitation within the walls of the inquisition; but the victim resolved that the public should have the opportunity to pass sentence. He accordingly drew up a true and literal account of the interview with bishop McTyeire, and published it in the *Nashville American* of June 16, 1878. This opened the door for a unanimous and outspoken condemnation of the act of the Board of Trust, from the press of the South and the country at large, and from representative individuals of every shade of religious opinion.† No word of approval rose from any source, except a few, feeble and perverting misstatements from the organs of the M. E. Church South. The best of reasons existed for the belief that the officials of the university very soon began to regret their action, and that within a few months they were ashamed of it. It was not long before the action was attributed by some of the officials, covertly, *to grounds of economy*. The impossibility of this is evident enough when it is known that Prof. Winchell's work was simply transferred to Prof. Safford (who had been on half duty) and *Prof. Winchell's salary with it*. Learning that this subterfuge was being set up by parties in correspondence with Dr. A. E. Foote, of Philadelphia, Prof Winchell wrote a crisp and peremptory denial of such statements which Dr. Foote published in his periodical, *The Naturalist's Leisure Hour*, January, 1880, p. 5.

So far as Prof. Winchell's standing and reputation were concerned these events were far from disastrous. He received new sympathy and appreciation from every intelligent man and woman and from many who otherwise would perhaps have remained in ignorance of his existence. Ex-President Andrew D. White, once Dr. Winchell's colleague at Ann Arbor, made use of this incident in one of his chapters on the "Warfare of Science," characterizing the action of Vanderbilt University in the following words:

> It is pleasing to know that while an institution calling itself a university thus violated the fundamental principles on which any institution worthy of the name must be based, another * * * recalled Dr. Winchell

† The events of this episode are all preserved in elaborate clippings from newspapers which fill two large scrap books.

at once to his professorship, and has honored itself by maintaining him in that position where, unhampered, he has ever since been able to utter his views in the midst of the largest body of students on the American continent. Disgraceful as this history is to the men who drove out Dr. Winchell, they but succeeded, as various similar bodies of men making similar efforts have done, in advancing their supposed victim to higher position and more commanding influence.

He returned to Ann Arbor and again applied himself to his long-promised volume, interrupted, as before, by engagements to lecture at summer assemblies. Nevertheless he added, as he states, 52,500 words to his manuscript, before his departure, 15th Sept., 1878, for Syracuse.

This year, instead of writing a series of studied lectures, he restricted himself to extemporaneous, and doubtless more popular, expositions. The lecture which he delivered in New York, Oct. 25, in the Academy of Music, before the Delta Kappa Epsilon Convention, published in the New York *Tribune*, was very highly commended by all who were alive to the progress of ideas in education; and was repeatedly republished in educational journals. The theme was *A Plea for Modernized Education.* Having been invited to repeat the lecture in Syracuse, before the public, he wrote another entitled, *Culture and Knowledge*, in which, while still maintaining the proper precedence of science, he dwelt on the value of culture, but insisted that it comes from the study of things valuable for knowledge, as well as the study of dead anguages. This was published in full in the *Syracuse Courier* for Nov. 17, 1878. It received even more attention than the earlier address. He also delivered two or three other public addresses in Syracuse, which elicted very favorable comment from the press. The *DailyJournal* of Nov. 16, said:

> There has been a growing interest of late in the utterances of this distinguished scholar. His last lecture, on the subject of education, is spoken of by all who heard it, as extremely eloquent in its delivery and brilliant in its thought. * * * Dr. Winchell deserves a warm place in the hearts of the Christian public for his masterly defense of the Bible, and his eloquent pleas for a full and symmetrical culture, including moral and religious as well as intellectual development. He is a christian scientist of the highest type; and Syracuse may well be proud to number him among her most distinguished citizens.

Returning to Ann Arbor again he gave his leisure to the preparation of a work to be entitled *Preadamites*. He desired to investigate the subject further for his own satisfaction, and also to

demonstrate to the world that a doctrine which had been denounced as heresy is sustained not only by ethnology, archæology, chronology and biology, but by the Bible itself. Notwithstanding prolonged absences from home on lecture engagements which took him as far west as Iowa and Nebraska, he completed the manuscript by May, 1879. The work appeared in April, 1880, from the publishing house of S. C. Griggs & Co., Chicago. The following is from its preface:

I have not assumed a position hostile to the Bible: it would have been irrational for me to do so: since it is the assertion of the Bible which determines what we are to understand by Adam. Had the Bible affirmed explicitly that Adam had no progenitor, I should simply have declared the facts of the genesiacal history inconsistent with the affirmation, as the facts of science would also be. I have even devoted a chapter to the proof that Preadamitism is neither inconsistent with the Bible nor with the orthodoxy of approved divines. More particularly, I have not disputed the divine creation of Adam, even in maintaining that he had a human father and mother. I have not impaired the unity of mankind, but have removed the incredibility of that doctrine as grounded in the descent of negroes and Australians from Noah and Adam. I have not affirmed—even like McCausland and other ecclesiastical polygenists—that mankind, one in moral nature, are not one in origin: since I hold that the blood of the first human stock flows in the veins of every living human being. I have not excluded the Preadamites and their descendents from the benefits of the "Plan of Redemption:" since I maintain that all mankind are equally the subjects of redemption. I have not degraded Adam below the level on which the Bible places him, since I do not recognize him as the starting point of humanity. Finally I have not pictured man as risen from the organic grade of a brute since I wished only to show that he was in existence before the "first man" of the Hebrews.

1879. He lectured at Potsdam, N. Y., in May, 1879, under the auspices of the Normal School. He had delivered a popular lecture there the autumn previous. Returning home he first wrote an article on the *Metaphysics of Science*, requested by the editor of the "North American Review," which appeared in the No. for January, 1880, and returned to the completion, or at least the farther prosecution of his great work—grievously interrupted however from day to day by the varied calls which exhaust the energy and steal the time of a professional man.

In June, 1879, he was unanimously recalled by the Board of Regents of the University of Michigan to the chair of geology and paleontology in that institution. For several years such had been the intensity of a factional spirit in the Board, that scarcely any

measure and been adopted without dissenting votes. When, therefore, the unanimity of the Board in voting for his return was made known, and the general wish of the faculty of the university was understood to sustain the action, he did not hesitate to return to the institution from which he had been tempted six years before. The university had progressed in the previous seven years. The position now offered embraced much more favorable conditions for scientific advancement than the position he had left. His duties at that time were spread over the whole field of geology, zoology, botany, museum and microscopical work. When he returned the faculty embraced a professor of geology and paleontology; a professor of mineralogy and economic geology; a professor of zoology; an assistant professor of botany; an instructor in the microscopical laboratory, and a curator of the museum, all of whose duties devolved upon one man in 1872.

In his small pamphlet, *Geology of the Stars*, he presented the first generalization of the history which subsequently was expanded into *World-Life*. His conception of geology, as a *history of the earth*, led to a grasp of all its history—to the remotest limit of time, past and future. Thus geology was welded to cosmogony. The search for conditions still antecedent to those revealed by the remotest stretch of the vision of science led him into the field of metaphysics. The central idea of all his lectures of this class was *the life-time of a world*. Sometimes the great theme was compassed in a single lecture, sometimes in two, and perhaps more frequently it was expanded, especially in his university courses, to six or eight, and in one of his later courses it was constituted a series that extended through the time of a whole term. Every separate lecture was a chapter in the grand story. No lecture had a fixed form of words, nor subject matter. The selection of the topics and the degree of expansion to give them were determined always by the proprieties of the occasion, and the whole body of language, and many of the illustrations, were such as were prompted by the hour.

He now began, on his return to the university to which he had given the labor of his earlier years, the preparation of an extended *syllabus* of a course of instruction in general geology. This is accompanied by copious references to sources of information—a sort of geological bibliography. The first part of this compilation relates to the *facts of geology* and the second to the *theories of*

geology. It is a valuable pamphlet of 115 octavo pages, mostly in small type, and contains over 4,000 references to geological authorities. This work he regarded as a basis for a contemplated larger volume for scientific students and investigators, and he added to it, in his interleaved working copy, a multitude of additional notes.

1880. His work on Preadamites was published in April, 1880. The book had been largely ordered in advance, and sold well from the start, so that though the first edition consisted of 1130 copies, the publishers began on a second edition within two weeks, and a third was called for by November. The fifth has now been issued some new matter having been added just before the author's death.

As a literary production this work was received with universal favor. As to the positions assumed it is noteworthy that most of the religious journals either occupied a non-committal attitude, saying time was required for due consideration, or else they dogmatically condemned the doctrines of the book. The Presbyterians, Cumberland Presbyterians,* and Northern Methodists treated the discussion with most intelligence, and therefore with most tolerance. The Baptists and Episcopalians and Southern Methodists generally denounced the book and sometimes the author, without the slightest attention to the tenability of the positions assumed.† On the contrary the secular and scientific journals received the work in a very favorable manner. Of the secular papers some criticised the author for giving any attention to the mode of reconciliation between Preadamites and the Bible; and one or two seemed disposed to ridicule for an alleged pro-clerical development. This criticism of course was offset by those orthodox reviewers who relegated the author to the limbo which holds "Darwin, Spencer and Huxley," and such like.

The following are quotations from some of the characteristic reviews:

"There has been no work recently published upon the subject which can compare with this in importance. Professor Winchell's reputation for learning and for sincerity, his repute as a student of physical science, and his special attitude toward what is called the conflict between science and religion render anything which he writes upon such a theme important; and the present work is the more likely to attract attention

*See Review for Jan., 1881.

†See *Southern Methodist Quarterly Review* for Jan., 1881.

because it is the fruit of an exhaustive study, not of one but of all the sources of information which can be supposed to throw light upon the question, from the text and history of the Hebrew scriptures to the latest results of ethnological investigation." —*New York Evening Post.*

This book gives us the amplification, and we believe the unanswerable defense of views which, upon their promulgation of two years ago, cost professor Winchell his lectureship at Vanderbilt University. * * * This great scholarly work shows its author alive in every fiber. * * * The book is splendidly written, many passages of great beauty might be selected from it. It shows its author to be a man of mental power, great information and extraordinary culture.—*New England Journal of Education.*

There is hardly a subject relating to human progress and religion that is not connected in some way with the contents of this extraordinary production, and the writer shows that he is thoroughly equipped for the task which he has so brilliantly accomplished. Prof. Winchell has a highly cultivated literary gift, and the style of his composition is clear, easy, graphic and vigorous. But while the book is popularly written its spirit and method are strictly scientific. The candor, logical acuteness and learning of the author will favorably impress the most prejudiced. We regard the treatise as a remarkable and powerful contribution to the reconciliation of the Bible and modern science. No doubt some will draw inferences as to professor Winchell's teachings that are alien to his belief; but if they do it will not be because his disavowal of certain doctrines is not sufficiently explicit.—H. N. POWERS, *in the Literary World, June 5, 1880.*

* * * Dr. Winchell's book has a double interest which should not be overlooked. Though making no claims of this nature it is yet a valuable exposition of ethnological science, treating instructively a wide range of questions in relation to the origin, distribution, characteristics and natural history of the human races. * * * But while useful as a mere didactic discussion of anthropological questions, the work has an interest of another kind in relation to the special object for which it was written. It is an able contribution to a serious modern controversy. * * * It is not too much to say that it settles the controversy: and all christian teachers who have any genuine interest in the adjustment of their beliefs so that they shall harmonize with scientific demonstrations, owe gratitude to the author of this work for the untiring labor that he has bestowed upon the inquiry, and the intrepid spirit in which he has pursued it.—*Popular Science Monthly, July, 1880.*

Alexander Winchell, already a recognized authority in several branches of scientific knowledge, in a volume recently issued with the above title, sings the *Ilias humana.* If it were clothed in rhetoric it would deserve to rank as the epic of epics. * * * It has the thrilling interest of a romance.—*The Bulletin, San Francisco, 22d May, 1880.*

Similar tributes were paid to the work by the Montreal *Gazette*, the Boston *Traveller*, the Rochester *Morning Herald*, Trübner's

Literary Record (London), the *American Naturalist*, the ***Bibliotheca Sacra***, the *Methodist Quarterly Review*, the ***Scotsman*** (Edinburgh), and many other prominent journals.

During the winter of 1880 and 81 he was engaged on "Sparks from a Geologist's Hammer." Some chapters on cosmogony, however, expanded under his hands to such an extent that he determined to withhold them and develop this subject into a separate work. He accordingly supplied their place with some new chapters, reserving the discussion of cosmogony for more leisure.

Having been elected professor of geology and paleontology in the Martha's Vineyard summer institute he delivered 25 lectures before a class of students, and five more popular lectures on scientific subjects before the public. He also, meantime, delivered a public address on the *Speculative consequences of Evolution* before the "Institute of Christian Philosophy," at Greenwood lake, on the boundary between New York and New Jersey. At Martha's Vineyard he made a large collection of Algæ, adding some specimens from Nahant and Marblehead. These were studied and carefuly mounted in an album volume after returning home.

At Ann Arbor he gradually became connected with some musical organizations, and gave much time to the perfecting of their organization. The central organization, was the University Musical Society, incorporated under the law of the State, of which he was chosen president. This society organized three agencies: 1. The Ann Arbor School of Music, of which he was vice-president of the Board of Trustees. 2. The Choral Union, of which he was president, and 3. The Orchestra. These organizations absorbed much of his time during the following year.

1881. His work, *Sparks from a Geologist's Hammer*, appeared in the early winter of 1880-81. It was favorably received and met with a large and immediate sale.

This superb work is of thrilling interest to every reader who has an intelligent desire to know more of this wonderful planet on which we live. * * * The chapter, "A group of Geologic Time," is worth more to the general reader than the price of the whole book. * * * The plan of the book is most admirable. Prof. Winchell's first chapter takes the reader upon an interesting excursion to Mount Blanc and the Mer de Glace, where the æsthetic aspect of Geology, as there so beautifully displayed, is presented. This is followed by three chapters, on the "Old Age of Continents," "Obliterated Continents," and "A Grasp of Geologic

Time," following with other chapters, climatic, historical and philosophical. It is a treasury which should find a cherished place in every family library.—*Boston Home Journal.*

Dr Winchell's *jeu d'esprit* on the "Genealogy of Ships," (Chapter XII of this volume) remains one of the most influential contributions ever made to the literature of Evolution.—*New York Observer.*

1882. An article on *Darwinism* prepared for the American supplement of the "Encyclopedia Britannica," at the urgent request of the editor, in June, 1882, did not appear in print till 1884. The summer of 1882 was again spent at Martha's Vineyard. Besides his regular courses of lectures here, he gave the principle dedicatory address at the dedication of "Agassiz Hall." This, with full abstracts of his other popular lectures, was published in the Institute Herald. The abstracts were also published in the *Boston Journal of Science.*

In the summer, at the Montreal meeting of the American Association for the Advancement of Science, he was chosen to preside over the section of Anthropology, in the absence of the regular officer. In the autumn he wrote *The Experiment of Universal Suffrage* and *Communism in the United States* which were solicited and published by the proprietor of the *North American Review.* Declining various other similiar solicitations he now resolved to devote himself to the completion of his long planned work on *World Life*, and he accordingly devoted to this most of the leisure found among the numberless duties, diversions and petty distractions of domestic, social and professional life. He yielded to perhaps a dozen requests to deliver popular scientific addresses, mostly within the state of Michigan.

In 1883. The work upon *World Life* involved a great amount of study and research. The subject had indeed occupied his thoughts for many years, and many of the processes had been reasoned out in all their detail. But he desired now to present the discussion in greater completeness and upon a more vigorous basis of scientific evidence. The field widened as he proceeded. New avenues of research were disclosed. Following these, one after another, he developed conclusions which were unexpected, and new, and some of which were an interesting surprise to himself. Sometimes he pursued these researches by the aid of mathematics, and all the old ardor of his earlier years was rekindled. In several instances he made attempts to submit his methods and results to competent critics. His speculations on the influence of

cosmic tides, and on meridionality in the earth's structural features, had been submitted, in 1882, to Prof. James D. Dana. Later he proposed to bring them under the notice of Dr. J. E. Hilgard, of Washington; but no criticisms or judgments could be obtained, professor Hilgard saying he was not familiar with that range of investigation. His conclusions on the evolution of heat by processes of contraction he brought before the Ann Arbor Scientific Association (of which he was president) on the occasion of two meetings, in the hearing of professors Harrington and Wead, likewise the subject of annulation of nebulous masses, and the width of the resultant ring, with a view of eliciting opinions. Twice Prof. Wead was invited to his study for the discussion of certain points—especially M. Faye's modification of the "nebular theory" as presented in *Comptes Rendus* (xc, 637-43); but the subject was new to Prof. Wead.

Whatever new processes or results, therefore, there may be found in *World Life* were worked out by its author in complete isolation from all living thinkers. Very much of it was pioneer work, and the mathematical instrument employed had been long disused. He felt that great danger existed of falling into some grave errors, and he knew that as soon as they were in print and beyond recall, there would be a class of scientific critics who would take any pains to demonstrate their smartness. He greatly desired to submit points in his manuscript to the examination of experts, but there seemed to be nobody prepared to act in that capacity. He therefore had to assume all the risks or forego the publication.

It was during the concentration of nervous and mental energy on this volume that he was called on, during the disability of Dr. B. F. Cocker, both by the president of the University and by Dr. Cocker himself, to conduct the latter's class in speculative philosophy. He continued Dr. Cocker's method—a daily lecture—and he here drew upon his manuscript volume on "Intelligence and Religion;" and he put a synopsis of the "Theistic Argument" into printed form, in all its ramifications, for the use and at the instance of his class. In a similar manner he condensed, into a synopsis of eight octavo pages, his whole work (yet unpublished) on "Intelligence and Religion." In consequence of this double duty it appears that one of the secondary effects of the malady with which he was suffering, as made apparent by the post mor-

tem examination, was intensified, and caused a temporary disablement. It was manifested in continued headache, and Dr. Dunster, of the medical faculty, was called for advice. He expressed the opinion that mental effort too unremitted had produced a chronic congestion of the capillaries at the base of the brain. Whether the diagnosis as to cause was correct or not, as to effect there can now be no question, since the blood vessels at the base of the brain, as well as in other parts of the body, and especially the aorta, were "congested" and contracted by ossification.

Dr. Cocker having deceased in April, the University Senate requested Prof. Winchell to deliver a memorial discourse on the Sunday of Commencement week. This was delivered on June 24, and it was published in pamphlet form by the University. Dr. Cocker had been intimate with Dr. Winchell for many years. Their community of study had affiliated them, and a touching personal regard was felt mutually. Nothing could excel the reverent, tender and beautiful tribute which he now paid to the life and personal character and the work of his lost colleague. He wrote tender and appreciative memorials of several of the University faculty when deceased, but into none of them did he throw the ardor of his love and the polish of rhetorical expression and the searching analysis of character that marks this paper. It will probably long remain the model, par excellence, of obituary memorials of deceased professors at Ann Arbor.

His "World Life, or Comparative Geology" was issued in November, 1883. Its scope is set forth modestly in the opening passage from the preface as "a thoughtful view of the processes of world formation, world growth and world decadence." The subjects discussed are the most elevating and sublime within the range of human knowledge. It was well received by the public, as well as by scientific critics.

One of the ablest works of the day. In involves conceptions whose tremendous scope takes one's breath—before whose awful magnitude even imagination hesitates appalled; but among these vast themes Dr. Winchell moves with the assured step of a familiar.—*Chicago Times.*

This volume is Dr. Winchell's masterpiece. It furnishes us a magnificent survey of universal structural cosmogony, such as has not hitherto appeared.—*Methodist Quarterly Review*, Jan., 1884.

There is something very fascinating in the book, so grand and simple are its generalizations, so vivid is its panorama of the mighty courses of creation, so like a romance of the heavens does it read, with its orderly

evolution of dramatis personæ rising out of the limitless spaces, passing across the astronomical stage and descending again into the depths whence they rose. It is a work of immense learning.—*New York Home Journal.*

The systematic and very comprehensive way in which the author has treated most of the important questions of the day that concern equally the sciences of astronomy, geology and physics, makes the work a most timely one, and the candor, research and independent thought which have been given to this task are points of excellence that the scientist as well as the popular reader will appreciate. * * * * A perusal of the book has led the writer to think that it is one of the most important contributions to science that has appeared in America, at least for years. --*The Sidereal Messenger.*

We know of no other work in which the reader can find a full, connected and systematic presentation of the results of cosmical research that will compare with this.—*Popular Science Monthly, Feb., 1884.*

1884. In rapid succession appeared "Geological Excursions," a rudimentary book for young learners in geology, and "Geological Studies," a text-book of higher grade, both published by S. C. Griggs & Co., of Chicago. The immediate instigation to the preparation of the former was a request for such a work from a Boston publisher. It appeared in May, 1884. It is on a plan entirely new among text-books of geology. The effort was made to do for geology what has been done especially for botany, in directing the learner's attention to the characters of some of the most familiar objects, instead of putting before him an array of abstract definitions, theories and classifications which cannot be appreciated by those faculties in easiest and most active exercise in the child.

He contributed an article to the *Homiletic Monthly* (N. Y.) in March, which appeared in a "Symposium" on the question: "Is the Darwinian theory of evolution reconcilable with the Bible?" Other writers in this symposium are Rev. Drs. Patton and McCosh of Princeton, and Dr. Gulliver, of Andover. He contributed matter amounting to 45,000 words to "Johnson's Animal Kingdom Illustrated," mainly on zoological topics, and distributed through 22 different articles. This was published in the early part of 1885.

1885. In the Supplement to "McClintock and Strong's Cyclopedia" appeared his article on Evolution. This is a general exposition of the subject—its definitions, history, doctrines, proofs, speculations, theories and literature, consisting of 9,000 words

His *Geological Studies*, on which he spent his leisure in 1885, was begun in November, 1884. The work has the same simple inductive method as *Geological Excursions*. The treatment is based largely on American geology. This work was interrupted by the Ann Arbor meeting of the American Association for the Advancement of Science, for which he prepared three communications, on *The Geology of Ann Arbor*, one on *Sources of Trend and Crustal Surplusage*, and the third on *Stromatoporoids*. The second paper appears in condensed form in the Proceedings, and in the American Journal of Science, December, 1885, in full. His third paper was orally presented in the Biological Section, and was illustrated by a series of micro-photographs of his own make, designed to show the interior and cellular structure.

1886. At the solicitation of Rev. Dr. J. H. Vincent, of Chautauqua fame, he contracted in December, 1885, to supply the manuscript for a work, afterward published as *Walks and Talks in the Geological Field*, to be ready by April 1, 1886. His "Geological Studies" was in press, his daily University duties were exacting, his professional interruptions were numerous and aggravating, but this exacting contract, on which he labored assiduously, was complied with, and the manuscript was written by February 15, and was in the publisher's hands March 19, 1886. Meantime from various directions came multiplied solicitations to write and to lecture, and to some of them he felt constrained to yield. Among them was a request for an article for *The Forum*. The subject of this essay was *Science and the State*. Another was *A Walk under the Sea*, written for *Treasure Trove*, New York. Lectures were delivered in Chicago and Rockford, Ill., and in several places in Michigan.

Early in May he delivered a series of lectures before the Rose Polytechnic Institute, at Terre Haute, Ind.—meantime receiving proofs daily from his publishers in Chicago and Cincinnati. Later he drew up, at the request of the director of the U. S. Geological Survey a manuscript of 102 pp. devoted to a history of the past geological surveys in Michigan.

As he passed through Chicago, July 1, on his way to the wilderness of northern Minnesota, he received from S. C. Griggs & Co., the first finished copy of his *Geological Studies*, the same day on which his *Walks and Talks* was put on the market from Cincinnati.

An engagement had been made in March with the Minnesota

Geological Survey to spend the summer in field-work in the extreme northern portion of that state, north of lake Superior. Accordingly he left home June 28, and did not return till Sept. 29. Three months were spent in arduous and trying work on the Archæan rocks in a wilderness far removed from civilization and mail connections, where for seven weeks at a time no opportunity existed to send or receive a letter. The surveys were conducted in birch bark canoes, along the rocky shores of hundreds of small lakes, and the passage from lake to lake was made over "portages." His work extended into twenty-four townships. He noted and studied the rock-outcrops at 890 localities, and passed over 123 portages whose aggregate length was 43 miles. These portages are foot-trails, more or less blind, through forests, swamps and hilly districts and at times are extremely arduous, even to one having nothing to carry. The observations made were important, and were found to throw much light on some of the problems of Archæan geology. The report on this work, in its official form, was published in the Fifteenth Annual Report of the Minnesota survey.

1887. Having lectured in Oct., ('86) at the Wayland Teacher's Institute, and at Chicago in November, where he found himself "posted, after the lecture in an advertised place where people who came to the lecture *to see him*, could take him by the hand and speak a word," and in Memphis, Tenn., where he was welcomed and entertained with the greatest cordiality, but where the clergymen declined on Sunday to make announcement of his intended Sunday evening lecture on *Science Christianity's Ally*, at Middletown, Ct., before the students, at Meriden, Ct., at Detroit and Armada, Mich., he spent the most of his leisure in the winter of 1886-87 in the study of Archæan problems connected with the preparation of his first Minnesota report. In March he received the provisional offer of the directorship of the Arkansas Geological Survey, then lately instituted, but in reply he imposed such conditions, (viz: that one half of his time should be spent at Ann Arbor) that the governor sought some one who could devote himself entirely to it, subsequently appointing Prof. J. C. Branner. In May he prepared a chapter on *Geology and the Bible*, published in Detroit in a volume styled *Signal Lights*, and others for the *Homiletic Review*, *Swiss Cross*, and *Forum* and prepared a description, with drawings, of a skeleton of *Platygonus compressus* found in

vicinity of a peat bed west of Osseo, Mich.* In June he delivered the commencement address at Ogden College, Bowling Green, Ky. and on June 24th was at Sault St. Mary, Mich., where he entered on an examination of the original Huronian region under the auspices of the Minnesota survey. At the banquet at the semi-centennial of the University of Michigan he represented the University of Bologna, in a brief address which is incorporated in the published volume devoted to the occasion.

On the Minnesota Survey he spent another season of arduous field-work. The observations which he made he considered very important, and they furnished the basis of several communications to scientific periodicals. The plan of the season carried him not only over the original Huronian area, but also over the iron regions of northern Michigan and Wisconsin, and finally into the area of the Animikie in northern Minnesota. He entered with great zest into the study and discussion of practical questions touching the stratigraphic relations of the older terranes, and his rapid noting of inspection carefully made in the field afforded a vast mass of data the discussion of which, in their full and final scope, he was never able to complete. July 19 he gave a public lecture at Ishpeming, Michigan, on *Evolution*, and Dec. 26, he read a paper before the Society of Naturalists at New Haven, Connecticut.

1888. He united with several other geologists in the establishment of the *American Geologist*, the first number of which appeared before Christmas, 1887, and throughout all its volumes may be seen the evidence of his zeal in its behalf.

He laid plans now to undertake the thorough examination and discussion of the data of the Archæan rocks. He not only proposed to investigate their field-relations, but their petrographic characters. He supplied himself rapidly with the necessary literature and apparatus. Although the undertaking was vast, and his health was precarious he entered upon the subject with the thoroughness and ambition of a man not yet out of his third decade. A new field of science was opened before him, and with the undaunted front which he always bore before such difficulties he resolutely attacked its strongest redoubts. He was annoyed, however, by applications for lectures and popular articles. These he now mostly declined—only appearing before the Brooklyn

*Mentioned in the *American Geologist*, vol. 1, p. 67.

Institute, the Syracuse University, the University Convocation at Albany, N. Y., and some places in Michigan.

At the Cleveland meeting of the American Association for the Advancement of Science he gave orally a statement before Section E. of some "Systematic results of a field study of the Archaean rocks of the Northwest." At a meeting of geologists for the organization of the Geological Society of America he was the chairman, and he also presided over the "organizing committee," both then and subsequently at the meetings at Ithaca, and was continued as chairman of the same committee for the purpose of preparing the permanent constitution and perfecting the organization.

A series of papers which he began in the AMERICAN GEOLOGIST on "Geology as a means of culture" were amplified and extended into a small volume which was concluded in November. This little work, entitled "Shall we teach Geology?" is intended to show that geology is adapted to younger pupils than generally are allowed to study it. Showing that it has those educational qualities that make it worthy of the highest esteem in a school curriculum, and that it is the result of a traditional preoccupancy of the field by other branches, that it is not admitted into the grades that precede the college course, he calls attention to the obstacles that lie in the way of a reform. The language is vigorous and direct, and the work has already produced a reflective reconsideration of school courses in several important educational centres.

1889. In pursuance of his Archaean studies he engaged in a review of American opinion on the Presilurian rocks, and communicated his results to the eighteenth report of the Minnesota survey. This review absorbed a vast amount of time and patient research. It is characterized by the fairness exhibited in the condensed statements of results and opinions of earlier geologists, and it forms a useful and very valuable compend for reference. At Toronto he presented further results of his work in northern Minnesota. At this place the revised constitution of the Geological Society of America was reported and finally approved. He had seen the whole history of this enterprise from the time it took some definite shape at Cleveland, O., till it had its first public meeting for the reading of papers, at Toronto, and had nursed it faithfully. He was gratified now to know that it had acquired the semblance as well as the substance of a healthful organization

capable of self-support. At the meeting of Section E he presented a paper on *The geological position of the Ogishke conglomerate*, in which he inclined to consider it as an integral part of the Keewatin formation. In 1889 he made several lecturing trips, viz., Ada, Ohio, Madison University, (N. Y.), Greenville and Hastings, Mich., Buffalo, N. Y., Hartford, Ct., and contributed various minor papers to journals, including a memorial of Dr. Henry S. Frieze, who had long been his colleague in the University of Michigan, published in the University *Chronicle*.

1890. The amount of work which he accomplished the last year of his life, as indicated by the diary and the field-notes which he kept, is amazing. A literal transcript of them would still but partially express it, since his regular class and museum and laboratory labors are not given in detail. A man in his state of health generally spares himself, by curtailing his daily labor, but it was quite the contrary with him. His work became more burdensome and multifarious. He shirked nothing. He did not even decline to answer the numerous letters which sought trivial information—some of which required several pages. He lectured in Chicago, Bowling Green, Hamilton, St. Paul and Detroit. He was several times in Washington, New York or Boston, to attend the meetings of the Organizing Committee of the International Congress of Geologists, and the Council of the Geological Society of America. In the summer he was geologist to the Rocky Mountain club, which made an excursion from St. Paul, traveling 4,971 miles in 13 states and territories, attended the scientific meetings at Indianapolis, where he presided over the Geological Society of America, projected, and in conjunction with the interested professors at Ann Arbor, prepared a memorial, accompanied by detailed plans, urging additions to the scientific laboratories of the University, presenting the same before committees and before the full Board of Regents, made a geological survey of a region near Echo lake in Ontario, on which he based his last communication to the Geological Society, "A last word with the Huronian," made a lengthy response to a toast "The University," at a banquet, in Detroit. He was president and director of the University Musical Society, president of the Board of the Wesleyan Guild, for which he prepared a pamphlet, giving its constitution, plan and purposes, president of the Trustees of the Methodist Episcopal church at Ann Arbor, and was just elected presi-

dent of the Geological Society of America. His letter-book for 1890 contains 487 copied letters. His published manuscript amounts for 1890, to 295 octavo pages, and that which remains unpublished is estimated at about 100 pages more.

1891. This year was begun with the same restless activity and far-reaching plans, but he soon found himself incapacitated. His sickness was brief, and he died, as already detailed, on February 19, 1891, when he was but little past 66 years of age.

III HIS SCIENTIFIC WORK.

The most of Alexander Winchell's work was scientific, but as he followed his researches in their remote ramifications he found himself articulating with other fields, and making the acquaintance of scholars who did not consider themselves scientists. All his processes and conclusions, however, were characterized by strict adherance to scientific evidence and methods. He differed from most scientists in that he did not hesitate to follow any line of investigation, although it was but secondary to his main purpose. Thus he was equally at home in most of the "natural sciences" and in mathematics, astronomy, philosophy and ethnology. Whenever his many-sided genius inspired him to enter upon a course of systematic study, his fertile pen, with a ready command of apt expression, recorded his observations and his thoughts, and this constituted much of his scientific work. He sometimes lamented that he was so "fatally balanced" that his energies, instead of being turned unitedly to one object were perpetually distracted by the prosecution of all in succession. His achievements, however, in almost any one of the sciences in which he labored, would constitute an honorable record, and when they are considered in their aggregate they mount up to a sum total which it seems almost impossible for one human life to compass.

It is not possible, nor perhaps would it be appropriate and profitable, here to enter upon an analysis of the scientific publications of Alexander Winchell, nor even to attempt to point out those facts and ideas which he added to the sum of human knowledge. The discriminating student, of the future, will be able, from the following list, to identify his publications, and to ascribe to each such value as it may deserve.

LIST OF THE PUBLISHED WORKS OF ALEXANDER WINCHELL, LL.D. 1850-1891.

1850. Abstract of Meteorological Observations at Amenia Seminary in 1849. *Report N. Y. Regents.* 1850.

1851. Catalogue of Plants found growing without Cultivation in the vicinity of Amenia Seminary. *Report N. Y. Regents.* 1851, pp. 256-279.

1852. On the Cold of the Month of January at Eutaw, Alabama, and on the Aurora Borealis of Sept. 29, 1851. *Amer. Jour. Sci. & Arts.* 2d. Series. xiii, 1852, p. 294.

1853. On the Geology of the Choctaw Bluff. *Proc. Amer. Assoc. Adv. Sci.*, vii, 1853, pp, 150-153.

1854. On the Location of the Agricultural College. *Mich. Agri. Rept.* 1854, pp. 343-356.

1855. On the Pursuit of the Natural Sciences. [Read before the State Teachers' Assoc.] *Mich. Journ. Educ.*, ii. 1855, pp. 152-161.

1855. The Shell Marls of Michigan. *Mich. Farmer, Sept.*, 1855, pp. 257-259.

1856. On the Importance of the Study of Natural History: [Read before the State Teachers' Assoc., 19 Aug., 1856.] *Mich. Journ. Educ.* iii. 1856, pp. 297-308.

1856. Notes on the Geology of Middle and Southern Alabama. *Proc. Amer. Assoc. Adv. Sci.*, x. 1856, pp. 82-93.

1856. Statistics of some Artesian Wells of Alabama. *Proc. Amer. Assoc. Adv. Sci.*, x. 1856, pp. 94-103.

1857. Theologico-Geology: or, the Teachings of Scripture Illustrated by the Conformation of the Earth's Crust, an Address delivered before the Bible Class connected with the Methodist Episcopal Church, Ann Arbor, Michigan... Ann Arbor: *Pamphlet.* 1857. 8° pp. 24. Printed by Davis & Cole.

1857. Guide to the Pronunciation of Scientific Terms. 1857. 12° pp. 12.

1857. Table of Cretaceous Rocks in Alabama. *Proc. Acad. Nat. Sci., Phila.*, ix, 1857, pp. 126.

1857. On Hair Worms. *Mich. Farmer*, July, 1857, pp.—.

1857. Superficial Deposits of Michigan and Alabama. *Harper's Geol. Rep. of Miss.*, 1857, 316-318.

1858. Voices from Nature, Creation the Work of One Intelligence and not the Product of Physical Forces, being the closing lecture of a course upon Geology and Natural History, delivered before the Young Men's Literary Association of Ann Arbor, Mich. Published by request of the Association. 1858. 8° pp. 26.

1858. Address before the State Teachers' Association, Ann Arbor, 20th Dec., 1857. *Mich. Journ. Educ. Jan.*, 1858, pp. 615.

1858. Report on the Michigan Journal of Education. *Mich. Journ. Educ. Jan.* 1858, pp. 26-27.

1858. Synoptical View of the Geological Succession of Organic Types. For the use of Students in the University of Michigan, and printed at their request, May, 1858. Ann Arbor. 8° pp. 7.

1858. Leaves from the Book of Nature. *Mich. Journ. Educ.* ii, 1858. pp. 74-77, 97-100, 132-136, 169 173, 193-197, 225-229, 257-263, 305-310, 353-356.

1858. Annual Report of Michigan State Teachers' Association. *Mich. Journ. Educ.* Sept. 1858, pp. 271-278.

1858. Outlines of the Geology of Michigan. *Mich. Farmer, Dec.,* 1858.

1859. Memorial Relative to a Geological Survey. *House Doc., No. 29. Legislature of* 1859. pp. 10.

1859. Scenes and Incidents of the Coal Period. *Mich. Journ. Educ.,* vi, 1859, pp. 13-20.

1859. A Chat About Teeth. *Mich. Journ. Educ.,* vi, 1859. pp. 20-25.

1859. Popular Solution of the Pendulum Problem. *Mich. Journ. Educ.,* vi, 1859, pp. 27-29.

1859. Public Instruction in Upper Canada. *Mich. Journ. Educ.,* vi,1859, pp. 48-52.

1859. Another Chat About Teeth. *Mich. Journ. Educ.,* vi, 1859, pp. 53-59.

1859. Museum of Comparative Zoölogy at Cambridge. *Mich. Journ. Educ.,* vi, 1859, pp. 134-141.

1859. Is Mode a Property of the English Verb? *Mich. Journ. Educ.,* vi, 1859, pp. 157-159.

1859. Public Instruction in Michigan. *Mich. Journ. Educ.,* vi, 1859, pp. 305-314.

1859. What Makes the Successful Teacher? An Address Delivered at Pontiac, August 18, 1859, before the Michigan State Teachers' Association. [From the *Trans. of the Assoc.* for 1859.] Ann Arbor, 1859. 8° pp. 22.

1859. How Shall our Standard of Primary Instruction be Elevated? *Mich. Journ. Educ.,* vi, 1859, pp. 433-436.

1859. Reorganization of the Agricultural College. *Mich. Journ. Educ.* vi, 1859, pp. 474-476.

1859. Report of the Visiting Committee, State Normal School. [A Criticism, on.] *Mich. Journ. Educ.,* vi, 1859, pp. 476-477.

1859. Is Natural History an Appropriate Study for Youth? *Mich. Journ. Educ.,* vi, 1859, pp. 477-478.

1860. The Cycles of Matter, or the Permanence of the Earth and the Destiny of the Race. *Mich. Journ. Educ.,* Aug., 1860, pp. 273-280.

1861. First Biennial Report of the Progress of the Geological Survey of Michigan, embracing observations on the Geology, Zoölogy, and Botany of the Lower Peninsula. Made to the Governor, December 31, 1860. By Authority. Lansing. 1861. 8° pp. 339.

1862. Notice of the Rocks lying between the Carboniferous Limestones of the Lower Peninsula of Michigan and the limestones of the Hamilton Group; with descriptions of some Cephalopods supposed to be new to Science. *Amer. Journ. of Sci.,* 2d series, xxxiii, pp. 352-366.

1862. Salt Manufacture of the Saginaw Valley. *Hunt's Merchants' Magazine,* Sept. 1862, pp. 209-223.

1862. On the Saliferous Rocks and Salt Springs of Michigan. *Amer. Journ. of Sci.* 2d series, xxxiv, pp. 307-311.

1862. Descriptions of Fossils from the Marshall and Huron Groups of Michigan. *Proc. Acad. Nat. Sci. Phila.*, xiv, 1862, pp. 405-430.

1863. On the Identification of the Cattskill Red Sandstone Group with the Chemung. *Amer. Journ. Sci & Arts*, 2d series, xxxv. 1863, pp. 61-62.

1863. Descriptions of Fossils from the Yellow Sandstones lying beneath the "Burlington Limestone" at Burlington, Iowa. *Proc. Acad. Nat. Sci. Phila.*, xv, 1863, pp. 2-24.

1862-4. Voices from Nature. *Ladies' Repository*, xxii, 1862, pp. 396-400, 488-492, 518-522, 577-581, xxiii, 1863, pp. 46-51, 72-74, 149-153, 201-204, 269-272, 385-390, 456-460, 518-520, 625-628, 678-684, 745-747, xxiv, 1864, pp. 31-33. [Sixteen articles.]

1863. Suggestions on the Nature, Method, and Subjects of Sunday-School Instruction. *Proc. Sunday-School Assoc. Washtenaw Dist.*, 1863, pp. 8-15.

1863. Description of Elephantine Molars in the Museum of the University of Michigan. *Canadian Naturalist*, Oct. 1863, pp. 398-400.

1864. Report Historical and Statistical on the Collections in Geology, Zoölogy and Botany, in the Museum of the University of Michigan, made to the Board of Regents, Oct. 2, 1863. Ann Arbor: Published by the University. 1864. 8° pp. 26.

1864. Notice of a small collection of Fossils from the Potsdam Sandstone of Wisconsin and the Lake Superior Sandstone of Michigan. *Amer. Journ. Sci. & Arts*, 2d series, xxxvii. 1864, pp. 226-233.

1864. The Oil Region of Michigan. Description of the Baker Tract, situated in the heart of the Oil Region of Michigan. Detroit, 1864. 8° pp. 7. Republished in *Amer. Journ. Sci. & Arts*, 2d series, xxxix, p. 350.

1864. Notice of the Remains of a Mastodon recently discovered in Michigan. *Amer. Journ. Science & Arts*, 2d series, xxxviii. 1864, pp. 223-224.

1864. Description of a Gar-pike, supposed to be new—Lepidosteus (Cylindrosteus) oculatus. *Proc. Acad. Nat. Sci. Phila.*, xvi, 1864, pp. 183-185.

1864. Geological Map of Michigan. Published by S. Geil, Philadelphia.

1864. On the Origin of the Prairies of the Valley of the Mississippi. *Amer. Jour. Sci. & Arts*, 2d series, xxxviii, 1864, pp. 332-344.

1864. Postscript to Prof. Winchell's article on the origin of Prairies. *Amer. Journ. Sci. & Arts*, 2d series, xxxviii, 1864, pp. 444-445.

1864. Meteorological Observations at Eutaw, Ala., and Ann Arbor, Mich. *Smithsonian Meteorological Observations*. 1864.

1864. On the Currant Worm of Ann Arbor, Michigan. *Amer. Journ. Sci. & Arts*, 2d series, xxxviii, 1864, p. 291-292. [Condensed from an article in the Detroit *Free Press* of July 9, 1864.]

1865. The Soils and Subsoils of Michigan. An Address delivered before the Executive Committee of the Michigan State Agricul-

tural Society in Representative Hall, at Lansing, Thursday evening, January 19, 1865. Published by order of the Legislature. Lansing. 1865. 8° pp. 30.

1865. On the Oil Formation in Michigan and Elsewhere.... From a report on the "Baker Tract," near Lakeport, St. Clair Co., Michigan. *Amer. Journ. Sci. & Arts*, 2d series, xxxix, 1865, pp. 350-353.

1865. An Act to provide for the completion of the Geological Survey. *Mich. Legislative Proc.*, Feb. 10, 1865.

1865. Notes on Selandria Cerasi, Harris, as it occurs at Ann Arbor, Mich. *Proc. Boston Soc. Nat. Hist.*, x, 1865, pp. 321-325.

1865. Geological Report on Certain Oil Lands lying in the Counties of Sanilac and St. Clair, Mich., comprising in all about 31,000 acres. Detroit, 1865. 8° pp. 8. With map.

1865. Descriptions of New Species of Fossils, from the Marshall Group of Michigan, and its supposed equivalents in other States: with Notes on some Fossils of the same age previously described. *Proc. Acad. Nat. Sci. Phila.*, xvii, 1865, pp. 109-133.

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[NOTE. Several minor papers and reports known to have been prepared by him in 1890 and 1891, are not yet published, or at least have not been seen in print. He had also recently done some work on a revision of the fossils of the Marshall group for the U. S. Geological Survey, being a continuation, with illustrations, of his memoirs of 1871. There is also, in manuscript, a work nearly completed, on *Intelligence and Religion*, and a large number of poems, essays and lectures. The foregoing list embraces nothing which was published in newspapers.]

IV. HIS OTHER WORK—NATURAL THEOLOGY, PHILOSOPHY, EDUCATION, HIS POPULAR LECTURES, POETRY.

It would seem as if early in his professional career Dr. Winchell laid down a scheme of philosophical postulates and their consequences, making 38 in all, and that all his subsequent writings and study were directed to the amplification and enforcement of this series. All the fundamental ideas of his later works and the ratiocination of his maturer years, whether published or unpublished, may be found in germinal condition in this early scheme. These logical steps were published in 1860, in the *Michigan Journal of Education*: "The cycles of matter: or the permanence of the earth and the destiny of the race." In the pursuit of this great theme he expanded the realm of geology over the entire history of the earth and its inhabitants, and over its associated worlds. When the inductive method failed him for lack of facts of observation he called to his aid imagination guided by logical relations. When he encountered man and animate nature, as parts of this cosmos, he sought to adjust them to each other and to their origin and destiny in the light of what knowledge he had, and when the light was faint he strove to increase it by reasonable speculation. Among his first writings of this kind was a series of articles on "Christian Theology illustrated from Nature," published in the *Northwestern Christian Advocate*, at Chicago. He was sensible that in these articles, which added much to the Butlerian method of "Analogy," there was still lacking an essential link, in that the validity of the cosmological argument was assumed rather than proven; he then engaged on an undertaking which he prosecuted with such diligence as his other duties would permit, till the last year of his life—an attempt to establish the validity of the "argument from design," resulting in a work that he entitled "Intellect and Religion," to which he frequently refers as his "belated work," his work "many times begun." It went through varied evolution in form of argument and in its general title, having been begun as "The Geologic Ages," revived as "A system of Natural Theology" and left with the above title. The work remains unpublished.

The burden of his educational labor lay in the direction of a widening of the avenues of natural science, and its introduction

into secondary schools. He insisted that the young student is more observing than reflective or analytic; that the education of the mind should be by an appeal to its most accessible and most powerful impulses, and that the influence of science on the human mind, especially in its formative stage, is more healthful to a normal growth, and more conducive to moral rectitude and more stimulating toward a right ambition than any other field of knowledge. He considered it a great mistake to fill the mind of the student with the quirks of an extinct syntax, and to "educate" him by familiarizing him with the questionable doings of the mythical gods and goddesses of the ancients. He believed that there is as much mental and ethical culture to be derived from the study of natural science, when pursued with equal thoroughness and exactness, as from the study of Greek or Latin literature or of mathematics.

His greatest achievements in education, however, were won in his own class-room. He was a living example of what he urged upon his pupils. In his lectures he was aglow with enthusiasm, but it was an enthusiasm that was deep-seated, and a glow that was steady and strong rather than hot and flashy. No earnest student could carry forward the course of study allotted to his department without receiving a conviction of the vastness as well as of the beneficent role of geology in human knowledge, and a profound sense of the grandeur of the thoughts which it inspires. He labored diligently and long in the University of Michigan, and he erected a durable monument in the hearts of his students, many of whom have testified reverently to the high ideals which his teaching inspired.

Along with his class-room work he conducted systematically some laboratory investigations, and in these, whether in paleontology or in lithology, he always had the presence and the attentive interest of some more advanced students. Owing, however, to rather adverse surroundings he was never able to equip a laboratory that was commensurate with the needs of his department, nor in harmony with his ideas of the importance of geology in the college curriculum.

His largest educational field, however, was the public platform. Here he was under no constraint by reason of youthful auditors. No limits were set to his rhapsodic scientific eloquence. No courteous regard for the amenities of possible professorial eti-

quette hampered the free flow of his criticism, or the exultant prophesy of the betterments of the future. All the fields of all knowledge were open before him. He could cull from them what suited his theme or his purpose. His soul rose within him as it expanded to embrace and express the grandeur of his thought, or to enforce the steps of his argument. His style was deliberate, logical or argumentative, full of comparison and illustration, seldom impassioned, graceful in delivery, rhetorical, oratorical. He was not a quick, impromptu speaker. His lectures had all been thought out, as to general trend, beforehand, but the particular phraseology, and the adapted illustration were the product of the moment. His success as a public lecturer was due to the completeness of his knowledge of his themes, the freshness and originality of his conceptions and the graceful rhetoric with which he spoke.

He was also a poet, "very much of a poet," as stated by Prof. Harrington.* There is a tinge of poetic sentiment apparent in much of his scientific writing. Poetic comparisons, allusions, quotations, either directly metric or in prosaic form, are scattered through the more staid discourse, in such a manner that their author is revealed as one having a lively poetic sense and a command of the best expression. Had he chosen to clothe his scientific outreachings into undemonstrated science in measure, he would have given to the English language much of the high cosmical poetry which Gœthe gave to the German. Most of his metric compositions, however, were confined to topics of personal and domestic nature, and some of them are particularly apt and touching. The following is from his poem delivered 15 July, 1872, on the twenty-fifth anniversary of his class, at Middletown, Ct.

> Oh, there is a life, within our life concealed--
> The scene of conflicts to no eye revealed—
> A shoreless depth, heaved in a starless night—
> Its billows swelling in resistless might
> And in the compass of its throes we see
> The conscious proofs of immortality.

Nothing could exceed the beauty of his short poem "To my dear ones in Heaven," quoted by Prof. Harrington.

In short, by his intimate knowledge of the higher relations of science to the good of man, and his sympathy with his nobler

*University memorial address, p. 24.

aspirations, Dr. Winchell's life and work stand to the young geologist as a monument to the altruistic and humane side of science, a field too often forgotten by investigators in the pursuit of abstract knowledge. His life and all his struggles were for the elevation of his profession, and the extension of its acceptance by humanity, upon whose support its progress depends.

V. CONCLUSION.

By the death of the senior member of the editorial board of the AMERICAN GEOLOGIST, the science for whose furtherance the magazine was instituted and has been maintained, lost one of its most earnest and successful students and teachers. Alexander Winchell was well known on both hemispheres as a philosophical geologist of no mean rank, a member of that company—always small in comparison with the main body—who do not limit their energies to one narrow field, but delight to range over the whole of their favorite science. No student now-a-days can be an "Admirable Crichton," master of the whole of human learning. In early times such marvels were possible. Nature was nearly unknown, and the earnest worker, favored with leisure, money and brains, could traverse the entire field and gather the crop which others had raised.

But with the rapid outward advance of the boundary line of the known and the correspondingly rapid increase in the number of the laborers, the task of even hastily running over so vast an area became too great for all save the few colossal intellects that the human race occasionally brought forth, and who tower above the heads of their fellows as intellectual giants. Even these few grow fewer with the passing years, and ere long it will tax or transcend the highest powers of nature to produce such prodigies —not that nature is failing, but that life is too short and faculty too weak to recollect or systematize the mighty mass of detail. Hence the rapidly increasing specialization of the present day.

The limitations of power, time and means imposed on most students confine their labor within narrow areas, that can be kept well within their mental purview. By the multitude of such workers is the careful cultivation of the whole field secured. Hence the great and increasing value of the few gifted by nature

with the larger or more powerful brains who if aided by time and means, or sometimes without them, can take a wider range and, entering into the labors of other men, can gather their results and combine them into one harmonious whole.

These two orders of mind are totally different. The former is cumbered with details. The latter is often accused, but wrongly, of despising them. So far is this from the truth that such minds are usually the most perfect masters of details. So perfect is this mastery that they never lose their way among them. As one traveling by compass may seem careless of local waymarks while following the higher guide, so minds of this order appear to go straight to their desired end as though led by a supernatural faculty that is perhaps incomprehensible by their fellows.

Without claiming for Alexander Winchell the highest position among these leaders of thought we think that every fair-judging scientist will at once allow that he deserves and will hold one of no mean rank. Himself a working geologist in the field, he was well acquainted with geological methods—a teaching geologist in the university, he was skilful in imparting his own knowledge, and in training others to habits of observation and investigation—a speculative geologist in the study, he boldly followed out the logical deductions from his premises to their uttermost attainable limits.

To those who knew him personally all this is perfectly familiar. Those who knew him only through his writings must be almost equally conscious of it. Few who have attended his lectures in the class-room or elsewhere can fail to testify that he possessed the rare and valuable ability of rousing interest and not unfrequently enthusiasm in his students. None can read his *World Life* without realizing that scientific imagination of a high order impelled the pen that wrote under the control of the strictest logic.

Mr. Hopkins, one of the few mathematical geologists of the first half of the present century, used to complain that mathematicians did not read his geological papers, and that geologists did not read his mathematical ones. The complaint was well founded, and if now made by another of the same school would be but slightly less true. Few geologists are competent for the latter task, and few mathematicians for the former. Various causes, many of them inevitable and natural, are responsible for this result. But the remark of Robert Mallett is not an exaggeration of

the truth that "to make sound progress all who profess to be geologists must first become mathematicians, physicists and chemists."

In this respect Alexander Winchell was an exception to the rule. Without claiming rank as an eminent mathematician, a standing which few working geologists can ever attain, he fully appreciated the immense advantages which his favorite science might obtain from the labors of her sister, and not a little of the fascination that attracted and held his hearers may have been due to this willingness and ability to follow the mathematician in his reasonings, and even in his speculations on the past and the future of the earth.

Among the works that came from the pen of our lamented colleague no one in our opinion will take and hold a higher place than "World Life." In making this remark we do not intend to imply any comparison to the disadvantage of his other writings. These are and will long be of immense value, especially in awakening an interest in the study of geology among those who have not previously directed any attention thereto. But others have written, and written well in the same way, and with the same result. We are not however aware of any systematic work in the English language that covers the field chosen by Alexander Winchell in his "World Life." Largely drawn, as he himself is the first to acknowledge, from the writings of others too numerous to name, the data and the deductions are here thrown into a connected whole, so far as is yet possible, and with these scattered fragments of material the author has succeeded in laying the foundations of a new science—one in which the geologist no longer limits his attention to the earth, his home, but grasping as a central and cardinal principle the consanguinity of the universe, rises from terrestrial details to cosmical generalizations, and enlisting in his service the astronomer, the chemist, the physicist and the mathematician, deduces from their data the conclusions to which, given time and the continuance of nature's present order, they must inevitably lead. For these reasons we regard the work as the author's master-piece, and in spite of all its defects and errors which the future must supply or correct, we look on it as a monument which will long testify to the high mental qualities and wide intellectual grasp of the man and the geologist.

To the publication of "World Life" may be ascribed the introduction to the reading world of the new science of comparative geology or planetology. The domain which Alexander Winchell then entered had never before been trodden by human foot, save where here and there one and another had stepped across its line and had left his few footprints on the surface of the untraveled wilderness. Carefully mapping all these scattered and divergent tracks, he delimited the known, and starting from this base, he carried as by an initial triangulation, his original and independent investigations into the unknown beyond. Or, changing the figure, the known laws of physics furnished a sure and safe basis of reasoning, and combined with the observations of the astronomer, enabled him to venture off the firm ground of sense into that region of speculation—not of fancy—that was

> Neither sea, nor good dry land, a dark
> Illimitable ocean, without bound,
> Without dimension, where length, breadth and hight,
> And time and place are lost:
> The realm of Chaos and Old Night.
>
> —*Milton.*

In this chaotic region he has laid the foundations of a new empire—a new science—a science that shall one day read to us the history of the planets and the stars—the science of astro-geology, as he himself has happily termed it.

The conceptions which "World Life" brings before the reader are such as beggar the loftiest and wildest fictions of eastern or western fancy, and forcibly illustrate the beautiful words of Playfair that "Reason can sometimes go where imagination dares not follow."

Dealing with masses immeasurable, with æons incalculable and with conditions of temperature, pressure, etc., totally incomprehensible, he pictures before his readers the beginnings of being, the universe in its birth, and depicts the evolution of the various spheres through their periods of incandescent youth and cool maturity, to their ultimate extinction in cold and darkness—a destiny inevitable to worlds that move. Schiller sings, in his "Gods of Greece:"

> Sure as the pendulum's dead beat,
> Mere slaves to gravity and heat.

The theme was a congenial one, and the author revelled among

the scenes which his pen was portraying, indulging to the full that highest of all the faculties, a scientific imagination, whose existence and activity were indicated by the dreamy, far-off look not infrequently to be seen in his eyes. The feelings that the subject stirred within him may be seen in the following passage:—

"The firmament is careering in infinite space. Our homes are rolled along at seven hundred miles an hour, and are transported sixty-eight thousand miles in a day by the revolution of the earth in her orbit. The sun with his entire family is sweeping through immensity with a possible velocity of two hundred thousand miles an hour. And there must be some common motion of the whole inextricable maze of moving stars with a velocity to which fancy may assign what rate she pleases without restraint from science. This mighty waltz of cosmic dancers is joined by the gauzy nebulæ, animated as our own firmament by their own internal motions. In the midst of this universe of seething movements is our appointed home. The mind uplifted in the effort to contemplate them and grasp their method grows giddy and impotent. How sublime these activities. To what a numerous and lofty companionship does our little planet belong. Hard it seems to be imprisoned here while the realm of a universe tempts us to its exploration. How can human souls content themselves to roll and whirl through space during their mortal days and eat and sleep and trifle, like rats in a ship at sea, without wondering where we are and whither we are bound."*

It will scarcely surprise any one to learn that a man so much in advance of his time, whose conceptions of nature were so far ahead of those that then prevailed and to a less degree prevail still, should become the victim of suspicion and persecution. This "deadly original sin of the Reformed Churches," as Hallam has termed it, has not yet been reformed out of existence. It lingers still, and sometimes manifests in one way or another all its old strength and bitterness, as many of the leaders of science can from their own experience testify. Those who venture to doubt what the majority believe, or to believe what the majority doubt, must prepare themselves to stand almost alone—the position of the advanced guard everywhere and always. They must find what comfort they can in the thought that in the long run the majority are usually wrong, and that the right is always at first

*Slightly condensed from "World Life."

with the minority. True that human life is often too short to take in the long run, but in the present case we rejoice to know that our brother geologist lived to see much of his work accepted, and to realize that the unthinking many are coming on rapidly to acknowledge the rightness, or at all events the rights of the far-seeing few.

We need not repeat here the details. Such animosities are better buried in the limbo of oblivion as soon as possible, but all who have followed or are familiar with the life of Alexander Winchell, will recall, by the references already given to his personal life, the events to which we refer. We conclude with a renewed expression of our regret that by his death American geology has lost one of her foremost students and exponents, and that philosophical geology, the world over, has lost one of the few who combine the various faculties and attainments requisite for the successful prosecution of this exalted study.

J. Francis Williams.

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JOHN FRANCIS WILLIAMS.*

By J. F. KEMP, Columbia College, New York.

The name of Dr. John Francis Williams will always be associated in American geology with those of Newton, Irving and Lewis. His life, like their lives, was one of brilliant achievement, of great future promise and of sad untimely termination. Although his accomplished results were great, yet coming as they did, early in life, his friends could but regard them as indicative of the future, and there is thus together with grief for his loss, the regret that so many possibilities are nullified.

Dr. Williams was born October 25, 1862, at Salem, the county seat of Washington Co., N. Y., situated about forty miles northeast of Troy. He was the only son of John Martin and Frances A. (Shriver) Williams, who with his one sister survive him. His boyhood was passed at the beautiful family home, until at twelve years he was placed in St. Paul's School, Concord, N. H. Leaving this in 1880 he entered the Rensselaer Polytechnic Institute at Troy. He completed the studies of the course in Civil Engineering, and graduated in 1883, with the degree of C. E. Like many geologists he began thus his scientific work in the engineering school, but found his tastes inclining irresistibly to pure as contrasted with applied science. During August, 1883, he was assistant engineer for the Albany, Rutland and Granville R. R.,

*This memorial was originally prepared for the GEOLOGIST, but at the request of the secretary of the Geological Society of America, it was read at the Columbus meeting, December 29, 1891.

but in the fall following he became assistant in chemistry and natural science at his alma mater. He was brought especially under the influence of his teacher and warm personal friend, Prof. Henry B. Nason, whose influence was largely instrumental in shaping his subsequent career. During this period he made the tests of slates from the region about his home, whose published results are subsequently cited. In 1885 the Polytechnic Institute conferred on him the additional degree of B. S.

During the summer of 1884, he traveled in northern Europe, visiting the North Cape and the mines of Sweden and Norway. In the autumn, acting on the advice of professor Nason he matriculated at the university of Göttingen, and became one in a long and honorable list of American scientific men who have received their preparation at this famous seat of learning. While at Göttingen his work lay especially in mineralogy and petrography under the guidance of professor Carl Klein, now of Berlin, and in chemistry under professor Victor Meyer.

In the spring of 1885 he traveled through Italy and Sicily with professor Klein, and later was assigned the subject of his thesis in one of the extinct volcanoes of the former land. Through professor Klein, Dr. Williams came to know personally professor Rosenbusch of Heidelberg, to whose kind advice he was afterwards indebted in his American work. During the Italian trip referred to above, professor Klein had been given some specimens of igneous rock from Monte Amiata, an extinct volcanic pile that rises near the classic lake Trasimenus and forms the highest peak in Tuscany. They proved of such interest that they were entrusted to Dr. Williams, as suggestive for his thesis. With characteristic energy and thoroughness he proceeded to the region in 1885, and accompanied by a Swiss helper and a local Italian guide, he spent several weeks on the mountain, either camping or lodging in the little country inns. After his return to Göttingen he anticipated taking his doctorate in the summer of 1886, but the sudden call of professor Klein to Berlin, necessitated holding the examinations in the spring. He received his degree magma cum laude. His thesis was afterward published in the *Neues Jahrbuch*, and gained great praise in America as well as abroad. The paper is accompanied by four partial and twenty-two complete analyses of rocks, and by an elaborate map and three panoramic views. Its special interest lies in this. It traces the differ-

ences in rock types throughout one great, single, eruptive mass, which is shown in its central part to be a trachyte containing hypersthene and labradorite, but which passes toward the borders, at times into liparite, at times into andesite.

Professor Klein desired Williams to go to Berlin, become his assistant, and continue his career in Germany. For a time in 1886 the offer was accepted, but finally Dr. Williams returned to his home, and in 1887 became director of the technical museum of the Pratt institute in Brooklyn. The duties consisted in arranging and caring for very excellent collections of minerals and rocks, but the desire for wider opportunities for scientific investigation led him in 1889 to become honorary fellow at Clark University, Worcester. While in this relation he received overtures from professor J. C. Branner, director of the geological survey of Arkansas to describe the igneous rocks of the state. Dr. Williams secured leave of absence from Clark and entered on his Arkansas work as a volunteer, without salary, in October, 1889. In the summer of 1890 he was made honorary docent at Clark. This title, like his previous one, carried no salary with it, and merely afforded him a work room and headquarters, which, however, were soon transferred to Little Rock. Evidently his relations with the University were not regarded as anything very serious, for no mention of them appears in his final report.

Dr. Williams found a wealth of interesting material in Arkansas, and as the result of his collecting he published in 1890 the papers on Manganopectolite and Eudialyte cited below. In the fall of 1890 he returned to Arkansas and completed his work, remaining, with one or two trips east, until the summer of 1891. He had meantime accumulated the materials for his final and greatest work, Volume II. of the Annual Report of the Geological survey for 1890, and entitled the Igneous Rocks of Arkansas. The volume, which was distributed in December, contains 432 pages, 391 of which are by Dr. Williams alone. They give an accurate and exhaustive petrographic description of the syenites, elaeolite-syenites, leucite-syenites, the variations of all three, and describes the basic dikes which pierce them. Perhaps the greatest interest lies in the identification of leucite in these rocks, and in establishing Cretaceous leucite-syenites as a new variety, especially as leucite has hitherto been considered to be limited to the later volcanic rocks. The report is accompanied by beautifully

executed topographic maps and by many illustrations. Much of its success was made possible by the cordial support given Dr. Williams by professor Branner, but it bears on every page the marks of tireless and painstaking scholarship. Professor Branner bears witness in the preface to the enthusiasm and energy with which Dr. Williams carried it through, and the writer of this memorial, who was also associated in some minor portions of the work, can truthfully testify to the consuming interest which animated him. Dr. Williams had been appointed assistant geologist on the survey in 1891, and in this capacity his name appears in the report. In 1891, in connection with Dr. R. N. Brackett, he carried on investigations in certain minerals of the kaolin group, which appeared in the Amer. Jour. of Science in July last.

In June, 1891, the position of assistant professor of geology and minerology became vacant at Cornell University, and Dr. Williams received the call. He accepted, and after making the western excursion of the Geological Congress, attempted to take up his duties. But weakness and disease were already laying a heavy grasp on him. A severe attack of the so-called grip in March last had sapped his strength, and ill-advised methods of work had aggravated its results. Dr. Williams worked well but not wisely, and protracted his labors till two and three in the morning—such habits are specially injurious in the climate of Arkansas—and at last reduced him to the shadow of himself. The tax upon him was too severe and his constitution finally gave way. Paralysis attacked him and after an illness of about two weeks he passed away on the 9th of November, being just twenty-nine years of age.

It has never been the lot of the writer to know intimately a more generous, frank and loveable man than J. Francis Williams, and it is impossible to speak of him without feeling the deepest emotion. His character was such as to indescribably endear him to his friends and his abilities and preparation for his work were of the highest order. His results were such as to secure for him in all the future one of the most honorable places in the records of Amercan geological science.

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R. N. Brackett and J. Francis Williams, Newtonite and Rectorite. Two new minerals of the Kaolinite Group. *Amer. Jour. Sci.* III. XLII. pp. 11-21. July, 1891.

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THE PRE-CRETACEOUS AGE OF THE METAMORPHIC ROCKS OF THE CALIFORNIA COAST RANGES.

By Harold W. Fairbanks, B. S., of San Diego, Cal.

While engaged upon the State Geological Survey, during the past summer, I was called on to make an examination of Shasta and Trinity counties. At the close of this work, the main range of the coast mountains was followed southward through Tehama, Colusa, Lake and Napa counties, nearly to Martinez.

The results obtained, while of a most interesting nature, differ so radically from those of former investigators in this field, that though I am satisfied that they are, in the main, correct, yet I feel some diffidence in proposing them on account of the opposite views held by so many well known geologists.

If my views are correct it seems very remarkable that such serious mistakes should have been entertained with regard to the Coast Range geology, not only by the former state survey, but also by most of the other students in this field up to the present time; and it is apparent that, from the earliest beginnings of geological work in this state, the relation between the metamorphosed and unmetamorphosed rocks of the ranges near the coast, from San Diego to Del Norte counties, has been entirely misunderstood.

The views which I hold, based almost entirely upon field study in the region in question, and which I can substantiate by actual occurrences, are the following:

1. The impossibility, from a physical standpoint, of drawing the line between the Coast Ranges and the Sierra Nevada.

2. The metamorphic rocks of the Coast Ranges are pre-Cretaceous.

3. The Coast Ranges and Sierras are a unit as regards time of the main upheaval and metamorphism.

4. The upheaval and metamorphism of the Coast Ranges as well as Sierras is pre-Cretaceous, and consequently the slates of the gold belt cannot be considered Cretaceous.

5. The presence of pre-Cretaceous eruptives in the metamorphics of the Coast Ranges.

6. The serpentine is an altered eruptive and post-Neocomian (Knoxville).

7. No great non-conformity exists between the Knoxville and Chico beds.

The Coast Range system of mountains consists of a series of parallel ranges having an average width of seventy miles and a length of over four hundred. These extend parallel to the Sierra Nevadas and are separated from them by the Sacramento and San Joaquin valleys. At the opposite ends of these valleys the two systems of ranges unite, in Shasta county on the north and in Kern county on the south.

The Sierras consist in general terms, of a core of granite flanked, particularly on the west, by a great width of metamorphic rocks, consisting of slate and crystalline schists. Granite occurs also through the Coast Ranges, but usually in small areas, not arranged along one regular line of upheaval. The metamorphic rocks of the Coast Ranges, though including a large amount of slate, mica, and hornblende schists, are distinguished particularly by a silicious character. Sandstone, jasper, green quartzose schist, and banded flinty rocks are abundant, and are characterized, over large areas, by a wavy structure in the thin bedded varieties, and a secondary silicification in which the rock has been filled with a network of minute quartz veins.

Unmetamorphosed strata of undoubted Cretaceous and Tertiary ages, occur on the flanks of the metamorphic rocks, becoming particularly prominent through the middle Coast Ranges.

It was my purpose to determine, if possible, from a lithological and stratigraphical standpoint, the relation of the metamorphic rocks of Shasta county (the age of a portion of which was known, and believed to represent the northern extension of the

Sierra Nevadas) to the metamorphic rocks of the Coast Ranges of uncertain age, but suspected to be older than Neocomian.

To facilitate a thorough understanding of the subject it is necessary to quote briefly from the published views of the earlier workers in California geology, what has been understood by the term "Coast Ranges," and the difficulty in drawing a line between these ranges and the Sierra Nevadas. Prof. Whitney says: "We consider all those chains or ranges of mountains to belong to the Coast Range, which have been uplifted since the deposition of the Cretaceous formation; those, on the other hand, which were elevated before the epoch of the Cretaceous are conceived as belonging to the Sierra Nevada."* Prof. Whitney's views in Auriferous Gravels, published a number of years after the termination of the old Geological Survey, only make more emphatic his earlier declarations. He says: "The most striking fact with regard to the Coast Ranges is, that this very extensive group of mountain chains is of comparatively very recent geological age. It is made up of Cretaceous and Tertiary strata with no rocks older than these showing themselves in any portion of the complicated series of elevations which are properly included under the above designation."† Again we find the following: "North of parallel thirty-nine, as far as the Klamath river, there is much monotony in the structure of the Coast Ranges. The rocks are almost exclusively Cretaceous and often very much metamorphosed; jasper, serpentine, and even mica slate occurring in large quantities, and in the most irregular manner."‡ To show the impossibility of drawing the line between the Sierras and Coast Ranges on structural grounds, the following will answer: "The lower part of the Trinity and Klamath rivers seems to form the boundary between the Coast Ranges proper and that portion of the coast mountains which appear to belong lithologically to the Sierras. * * To an observer on any one of these peaks (granite mountains in western Shasta county), and commanding a wide view over the region, there seems to be no physical break between the Coast Ranges and the Sierra. Scotts, the Klamath and Siskiyou ranges of mountains seem to represent the summit continuation of the Sierra proper, and the Trinity mountains run into these from the south and from the Coast Ranges proper, without

*Geological Survey of Cal. Vol. I, p. 167.

†Auriferous Gravels, p. 16. ‡Auriferous Gravels, p. 23.

its being possible at any one point to say, here the Coast Ranges end and the Sierras begin."*

Dr. G. F. Becker, of the U. S. Geological Survey, follows Prof. Whitney in classifying the metamorphic rocks of the Coast Ranges as Cretaceous. In his monograph on the Quicksilver Deposits are many statements to this effect. The only exception he makes is that of the Gavilan range.† In addition he does not deny that older rocks may exist in other parts of the Coast Range, and have undergone a second metamorphism at the time of the upheaval of the Cretaceous.‡ Again he says, "No fossils older than the Knoxville group are known to occur in the Coast Ranges, and no known fact suggests the existence of older rocks, except the character of the limestone and gneissoid rocks of the Gavilan range."§ In the summary he says, "At the close of the Neocomian an upheaval took place with extraordinary violence, folding and crushing the rocks, and producing the first ranges along the coast of California of which any record remains."

As a result of his study in the Lassen's Peak district, J. S. Diller would place the dividing line between the Coast Ranges and Sierras in a depression of the Auriferous series, between Pitt river and the North Fork of Feather river.‖

Many other geologists of prominence have undertaken investigations in the Coast Ranges, but there seems to have been no protest made against the generally accepted classification of the metamorphic rocks.

No attempts to get at the true position of these rocks from their stratigraphical relation seems to have been made, though the merging of the Coast Ranges into the Sierras at both ends gives the best opportunity for such an investigation.

No fossils have been found in rocks which I recognize as belonging to the metamorphic series. An Inoceramus found in the sandstones on Alcatraz island was claimed by Prof. Whitney as certain proof of the Cretaceous age of the metamorphic rocks forming the San Francisco peninsula, on account of lithological similarity. This I consider no proof as I have seen the pre-Cretaceous rocks in several localities exhibiting so little meta-

*Auriferous Gravels, p. 24.

†Geology of the Quicksilver Deposits, p. 181.

‡Geology of the Quicksilver Deposits, p. 187.

§Geology of the Quicksilver Deposits, p. 186.

‖Geology of Lassen's Peak District.

morphism, that, aside from their stratigraphical relation it would be almost impossible to separate them from the Cretaceous.

A series of statements which may seem to carry weight are summed up by Dr. Becker.* These are based on the occurrence of the fossil Aucella which at present seems to be considered indicative of the lower Cretaceous. It is distributed quite generally through the shale and calcareous strata which are seldom metamorphosed to any degree. The occurrences mentioned by Mr. Becker as observed by himself and his assistants, and also by Mr. Gobb, are, as far as my observation has gone, invariably confined to what I consider, from a stratigraphical standpoint alone, as belonging to the Cretaceous, to say nothing of the lithological characters of the two formations; characters which are constant over great areas and widely distinct from each other. Besides this there is an abrupt transition from unaltered shale to the metamorphics. Prof. Whitney noticed this in many places On the theory of regional metamorphism, is it likely or even possible that such a sharply defined line could exist if both were concerned in the same upheaval and consequent metamorphism? It seems to me that we can come to no other conclusion but that the Cretaceous age assigned to the metamorphic rocks of the Coast Ranges is merely assumed and not proved. The finding of Aucella in the unaltered shales near the metamorphics is no proof of the Cretaceous age of the latter.

My work in Shasta county developed the fact that in addition to the fossiliferous limestone of Carboniferous age first reported by Dr. Trask and those described lately by J. S. Diller, there are several others rich in fossils. The most interesting discovery, however, was that of the existence of fossils in three different localities in the Auriferous series and on both sides of the limestone areas. These occur in slaty rocks conformable with the limestones and in part Carboniferous. No non-conformity between any of the metamorphic rocks was observed in the county, and I see no reason for doubting that the upheaval of all the metamorphic rocks took place at the same time. At the time of this upheaval an extrusion of granite took place along the line between Trinity and Shasta counties, forming the Trinity mountains. That this granite is more recent than the Auriferous series is proved conclusively not only by the metamorphism induced in the

*Bull. U. S. Geological Survey, No. XIX, p. 9.

adjoining slates, but also by the complex series of granitic porphyry dikes extending into them often for several miles.

In the southwestern part of Shasta county at Horsetown and on the Cottonwood creek occur the most northerly outcrops of the Horsetown beds, the upper division of the Shasta group. The lower division of this group, the Knoxville, or Neocomian, is that which has been confounded with the metamorphics. The Horsetown beds are totally unaltered and but slightly disturbed, dipping eastward from 15°-35°. They rest unconformably on granite and the metamorphic rocks.

The granite mass of the Trinity mountains terminates abruptly on the south, being cut off by a body of massive serpentine which forms the summit of Bully Choop; one of the highest peaks of the Coast Range. Directly south of the serpentine, along the crest of the range, we encounter green talcose and chloritic schists in which the silicification, characteristic of the Coast Range metamorphics, is well developed. The schists are somewhat crumpled with the appearance of minute veins and bunches of quartz which follow the cleavage planes in an irregular manner. These rocks are penetrated for several miles by porphyritic dikes, evidently offshoots of the granite on the north. This is positive proof that their period of upheaval dates back to the extrusion of the granite. These schists extend southwest along the summit into Tehama county. To the west and north in Trinity county there is a repetition of rocks somewhat similar but more quartzose. On the eastern slope are argillaceous schists, quartzites, and small areas of limestone, overlaid in places to a hight of twenty-five hundred feet by shales, sandstones, and conglomerates of the Horsetown period.

As the range is followed south along the western border of Tehama county it is found to maintain an elevation of over five thousand feet, while silification becomes more and more a characteristic of the metamorphism. Red jasper, a remarkably wide spread rock in the Coast Ranges, was observed first in southeastern Trinity county.

The unaltered shales and sandstones of the Shasta group become very prominent in Tehama county; having a width of over twelve miles. They dip eastward at an angle of from 30°-45°, sometimes becoming nearly vertical near their western boundary.

Near the Cold Fork of the Cottonwood and about two miles from the metamorphics, the first specimen of Aucella was observed. The strata here dip nearly vertical and are greatly broken. The rocks against which they rest consist of quartzites, crystalline limestone with poorly preserved fossils, thin cleavable shales highly metamorphosed, green talcose schists changing to contorted and silicified green schists on Tom's Head and westward to the North Yallo Bally where they are gnarled and knotted in the highest degree.

On Elder creek the Aucella is found in abundance together with other lower Cretaceous species, but the contact with the metamorphic series is not to be observed on account of a great mass of serpentine. Mr. J. S. Diller, who has investigated this region carefully, has proved that both divisions of the Shasta group are represented on Elder creek; the lower, the Knoxville, having a thickness of nineteen thousand nine hundred feet, while the upper or Horsetown is represented by six thousand one hundred feet of shale and sandstone. These two beds were demonstrated to be continuous from top to bottom without physical break.* This accords with the latest views of Dr. Becker, who found a commingling of the faunas of these two divisions at Riddles, Oregon.† Mr. Becker had previously announced that the great upheaval of the Coast Ranges took place at the close of the Knoxville.‡ The conformity shown to exist between the two divisions of the Shasta group is in perfect accord with my own observations. A very important fact results from these conclusions; since the Horsetown and Knoxville beds are conformable, and the upper, or Horsetown, rests unconformably on the metamorphic series in Shasta county, a fact acknowledged by all observers, then the lower or Knoxville, when present, must also rest unconformably on the metamorphic series, if it can be proved that these metamorphics are continuous with those of Shasta county. After a most careful tracing of the older rocks of Shasta county southward, I find it utterly impossible to draw a line of demarkation between them and the metamorphics of either Tehama, Colusa, Lake or Napa counties. There is no physical break.

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*Bull. Geological Society of America, Vol. II, p. 207.

†Bull. Geological Society of America, Vol. II, p. 208.

‡Geology of the Quicksilver Deposits, p. 460.

The line of contact between the Cretaceous and the older rocks has been particularly favorable for the intrusion of the periditi-tic rock from which the serpentine has been derived, and this together with a general covering of the rocks with soil makes it hard to find good exposures. The best contact observed was on Elk creek in Colusa county; here the soft black shales rest directly against the green silicified schists. A few hundred feet distant the shales have a dip of 40° to the east; as the contact is approached they dip more and more, finally becoming somewhat broken and reversed, while for several feet adjoining the schists they are crushed to a clayey mass. The change to the vertical green schists is abrupt. Toward the crest of the mountain five miles away they become more silicified. Black slate and hornblende schists are also to be observed in places. The clay at the contact has been formed by an upward movement of the metamorphic ridge, a condition noticed at several points farther south, and which, to a certain degree obscures the non-conformity. This is undoubtedly the reason for the apparent conformity between the Aucella bearing strata and the metamorphics of Mount Diablo, mentioned by Mr. Becker as a proof of the unity of the two formations.*

About the headwaters of Stony creek the Cretaceous is separated from the metamorphics by large areas of serpentine, and ancient porphyritic rocks in part amygdaloidal. Snow Mt. consists of jasper, silicious schists and hard sandstones. Along the ridge southward between Lake and Colusa counties glaucophane schists appear. Black slate becomes more abundant and is particularly well exposed on the North Fork of Cache creek, where it splits into large slabs when not too much crushed.

The eastern boundary of the metamorphic rocks follows a direction a little east of south, passing about three miles east of Lower lake, through the western edge of Pope valley, and then becomes covered with volcanic material so that it can be traced no farther. Two outlying areas are to be found to the east of this line. One forms a ridge near the head of Sulphur creek, Colusa county and consists of sandstone, schists and jasper, with dikes of old eruptives. From this ridge the aucella bearing strata dip in opposite directions. The other is of much greater extent, forming a high range west of Beyressa valley, with a length of

*Geology of the Quicksilver Deposits, p. 184.

about twenty miles. Capel creek cuts through the southern end of this ridge, and though in place the metamorphism is not great, yet the distinction from the Cretaceous is easily discernible. Cretaceous shales carrying Aucella outcrop on the west, but are separated by a dike of serpentine. On the east the shales rest directly against a body of dioritic rock, similar in appearance to numerous dikes with which the metamorphic ridge is filled.

On James creek, north of the Ætna mines an exceedingly interesting section is exposed. For two miles the creek has cut through slates, mica and hornblende schists, and ancient intrusive rocks. At the mouth of the cañon the hornblende schists are followed by a dike of serpentine three hundred feet wide. From this there is an abrupt change to the unaltered but upturned and broken shales of the Knoxville beds. In these shales a mile eastward on Pope creek Aucella is found.

About three miles east of Lower lake near the Knoxville road, massive sandstones considerably altered outcrop on the western bank of a little creek. The eastern bank about twelve feet away is formed of Aucella bearing shales and calcareous strata entirely unmetamorphosed and dipping eastward about thirty degrees. Unfortunately the actual contact is hidden by a slide of boulders from above.

These examples are sufficient to show that there exists in the Coast Ranges of California a series of rocks for the most part greatly metamorphosed and separated from the lowest Cretaceous not only lithologically but also by a great non-conformity.

No regional metamorphism is anywhere apparent in the Cretaceous rocks; whatever the nature of the disturbance to which they have been subjected, it was not of a metamorphosing character. In several instances, as at Sulphur creek and Knoxville, an alteration has taken place, but solely through thermal action.

In places the older rocks are so little altered as to be easily confounded with the Cretaceous, and close examination and familiarity with the regional characteristics are necessary to distinguish them. The Aucella is a widely distributed fossil through the Lower Cretaceous, and is it not likely that it would have been found in some portion of the slightly altered metamorphics if they really belong to the Cretaceous?

The exact age of the metamorphic rocks as yet remains unknown. They are probably not older than the Carboniferous, and

must have been concerned in the upheaval of rocks of that age in Shasta county. Portions of the metamorphic rocks of the Coast Range bear the closest resemblance to those of the gold belt of the Sierras, which were considered by Prof. Whitney to be not younger than the Jurassic. Dr. Becker has affirmed that the gold bearing rocks of the Sierras are in part Neocomian on account of the presence of a species of Aucella indistinguishable from one found in the Coast Ranges.* He reaches the conclusion that the Knoxville and Mariposa beds are of the same age,† including of course the metamorphic rocks of the Coast Range in the Knoxville. In speaking of the Coast Ranges as members of the western Cordillera system he says, "The earliest determinable portion of the Coast Ranges must therefore be considered as due to the same disturbance which added the gold belt proper to the Sierra Nevada."‡ And again an important uplift of the Sierra Nevada was contemporaneous with the first known upheaval of the Coast Ranges.§

Laying aside the conclusion reached by Dr. Becker concerning the occurrence of the Aucella in the Sierra Nevada, I fully agree with him in regard to the simultaneous upheaval of the two series of ranges, and that they belong to the same mountain system, and finally, that whatever can be proved to be true of the metamorphics of the Coast Ranges, with reference to the points under discussion, must also be true of the rocks of which the Mariposa beds form a part.

Granted now a pre-Cretaceous age for the rocks of the Coast Ranges, and their upheaval as contemporaneous with that of the Mariposa beds, we must, as a consequence postulate a pre-Cretaceous age for the Mariposa beds. These beds are an integral part of the Sierras and consist largely of black slate. I have traced them almost continuously for a distance of a hundred and twenty miles and found them enclosed in a great width of other metamorphic rocks. The upheaval of the whole was accompanied by an extrusion of granite well illustrated a few miles southwest of Mariposa, where the black slates abut against the

*Geol. of the Quicksilver Deposits, p. 201.

†Geol. of the Quicksilver Deposits, pp. 195-198.

‡Geol. of the Quicksilver Deposits, p. 211.

§Geol. of the Quicksilver Deposits, p. 212.

granite and have been metamorphosed by it.* Crystalline limestones probably Carboniferous are found on both sides of the Mariposa beds, and must have been concerned in the same upheaval. Northward toward Pence's ranch no physical break has been detected. At this place are Carboniferous limestones and slates in part of the same age. Carboniferous limestone is also found in the eastern part of Shasta county interbedded with slates. From all the evidence at hand I believe it is impossible to separate the Mariposa beds from the other metamorphic rocks of the Sierras, and consequently their period of upheaval, admitted to be the same as the metamorphic rocks of the Coast Ranges, is coeval with that of the Carboniferous of Shasta county and other parts of the Sierras.

With regard to the peculiar metamorphism of the Coast Ranges it was certainly pre-Cretaceous. The formation of a network of minute quartz veins, so wide spread, seems to be confined to the harder rocks which were broken and crushed in the violent orographic movements, while the more argillaceous rocks were reduced, often to a clayey mass impenetrable by the silicifying agencies.

The metamorphic series is also distinguished by the presence of much intrusive rock which, as far as my observation goes, does not appear in the Knoxville. These intrusions are so much decomposed that it is difficult to get at their real character. When the amygdaloidal structure is absent they closely resemble decomposed sandstone. Good exposures of them appear north and west of Clear lake, in Pope valley, and Capel creek. In the Geology of the Quicksilver Deposits it is stated that no pre-Tertiary eruptives are to be met with between Clear lake and New Idria.

Serpentine is the most common pre-Tertiary eruptive in the Coast Ranges. That it is younger than those just described is shown by the fact that it cuts both the Knoxville and metamorphic series. It was held by Prof. Whitney and his assistants to be an altered silicious or silico-argillaceous rock,† the magnesia having been introduced by some process of substitution. Dr. Becker follows in nearly the same line and endeavors to prove the origin of serpentine through metasomatic processes, either directly

*Tenth Annual Report of the State Mineralogist, p. 30.

†Auriferous Gravels, p. 19.

from sandstone or through the intermediate stage of a metamorphic crystalline rock.* Contrary to the foregoing views J. S. Diller speaks of the serpentines of the Coast Ranges, as altered peridotites.† That at least a part of the California serpentines are altered eruptives seems also to be the opinion of H. W. Turner,‡ W. Lingren and G. P. Merrill.

The general similarity of the serpentines and their stratigraphical position lead me to believe that they are all of the same geological age, and, as a rule, have resulted from the decay of a peridotitic rock. The eruption of the peridotite and its alteration to serpentine must have taken place prior to the deposit of the Wallala beds, for the latter, according to Dr. Becker, contain serpentine boulders.

The serpentine bodies of the Coast Range are generally more irregular in outline than those of the Sierras, owing to the greater amount of crushing which the metamorphics of the former region have undergone, but are always sharply defined and indistinguishable in appearance from those of the Sierras, the eruptive nature of which I think no one will deny.

A slight degree of contact metamorphism is often shown. This is well illustrated on the road from Leesville to Bartlett's Springs where some pre-Cretaceous argillites have been hardened and made to assume a dark metallic appearance near the contact. On Grindstone creek, Colusa county, the Knoxville shales have been metamorphosed for a distance of a hundred feet, the bedding obliterated and a noticeable hardening induced. Numerous other instances of this were seen in Tehama and Colusa counties. In many cases the effect produced by the serpentine has been obliterated by the movements which have taken place along the contact. The presence of the serpentine in dikes and irregular bunches in the Knoxville shales, and the inclusions of the shale in the former are proofs of its intrusion subsequent to the deposition of the Knoxville beds.

Dr. Becker bases his strongest arguments for the metamorphic origin of serpentine on the field relations existing about Knoxville, Napa county. The locality is on the eastern edge of one of the greatest serpentine areas of the Coast Ranges. Along

*Geol. of the Quicksilver Deposits, p. 121.

†Bull. Geol. Society of America, Vol. II, p. 207.

‡Bull. Geol. Society of America, Vol. II, p. 390.

the crest of the ridge above Knoxville, innumerable bodies of metamorphic rock are included in the serpentine, among these are slate, hornblendic, micaceous, and actinolite schists. These are arranged with their longest diameters parallel, and extend in the same direction as the mountain ridge, northwest and southeast. In addition there are lenticular bodies of diabase, diorite and fine grained porphyritic rocks. These crystalline rocks, as a rule, have no downward continuation, and like the similarly shaped masses of metamorphic rock were probably broken off from deep-seated portions, and brought up with the erupting mass. They are surrounded by a border one to two inches thick, of a mixture of serpentine with the original rock; a condition resulting from a slight penetration by the magma. From all observations it appears that the serpentine has been capable of effecting only a comparatively slight degree of metamorphism on the adjacent or included fragments of sedimentary rock. In all this region no transition from the metamorphic rocks to serpentine was observed. Here, as in many other places in the Coast Range, the serpentine is greatly crushed and often reduced to a shaly mass. This apparent stratification is one reason which led the earlier observers to classify the rock as metamorphic. Discarding the idea of a sedimentary origin, to my mind, it is due not so much to movements in the rock produced by the hydration as to dynamical action, which has been so pronounced in the Coast Ranges as to reduce argillaceous rocks to clay and sandstones to a crumbling mass, over stretches of considerable extent.

No important non-conformity between the Shasta group and the Chico could be made out, though there is no doubt about the Chico resting unconformably on the metamorphic series. J. S. Diller says that on Elder creek, Tehama county, no physical break could be made out between the Knoxville and the Chico.* H. W. Turner figures and describes the Knoxville and Chico beds of Mt. Diablo as conformable.† Neither was any non-conformity between these beds found by Prof. Whitney.

From the foregoing illustrations coupled with my own observations, I think we can safely say that no important non-conformity exists in the Cretaceous, and that it is utterly impossible that the great upheaval of the Coast Ranges could have taken place at

*Bull. Geol. Society of America, Vol. II, p. 207.
†Bull. Geol. Society of America, Vol. II, p. 400.

the close of the Gault, or Shasta period, as Dr. Becker has lately affirmed.* A small unconformity undoubtedly exists, due in part to the eruption of the serpentine, and in part to an uplift accompanying it. The extrusion of such an immense body of igneous rock as that near Knoxville, ranging from three to five miles in width, and twenty miles long, must have pushed back and tilted the Knoxville shales to a considerable extent.

I see no other way but to return to the views of Prof. Whitney with regard to the gold belt of the Sierras, that is, to a post-Jurassic upheaval. This upheaval accompanied by granite and affecting the region of both systems of mountain ranges simultaneously, gave rise at least to the Coast Range with its series of metamorphic rocks.

Concerning the evidence of the fossil Aucella, since standard authorities differ in regard to its exact time range, I see no reason why it might not have existed during the Jurassic in the Sierra region, and, since its geographic range is of great extent, have returned again to regions where favorable conditions existed, after the great upheaval which separated the metamorphic rocks of both the Sierras and Coast Ranges from the lowest Cretaceous.

RELATIVE ABUNDANCE OF GOLD IN DIFFERENT GEOLOGICAL FORMATIONS.

W. P. BLAKE, Shullsburg, Wis.

In the interesting notice of the "Universality of Gold" by Dr. Everette in the November issue of the AMERICAN GEOLOGIST, page 331, he says: "Therefore gold may be sought for in every geological horizon, and has thus been found in more or less paying quantities from the very earliest rocks up to the recent alluvial and drift formations," a statement which may be accepted as correct, but he proceeds to state:—

"However, in those veins of quartz which are found in the Cambrian and Lower Silurian strata, gold in the metallic state intermixed amongst the quartz is found in far greater commercial quantity than in any other of the preceding or subsequent geological horizons. Wherever gold has been found in very large quantity in either vein or placer form, it has been found to be

*Bull. Geol. Society of America, Vol. II, p. 206.

either in a Cambro-Silurian series of slaty rocks and quartz or else has resulted from the immediate decomposition of those rocks."

This last generalized statement would have passed unchallenged, and would have been generally accepted in the days of Sir Roderick Murchison, who came to regard the occurrence of gold as evidence of Silurian rocks, and conversely, the discovery of Silurian rocks, as for example in Australia, as indicative of the occurrence of gold, but to-day, after the experience in California, the generalization is not justified by the facts.

The age of the chief gold-bearing slates of the central gold region of California, where gold was mined in greater quantity than ever before, was for a long time in doubt. The dogma of the Lower Palæozoic age of most of the gold rocks of the world, predisposed observers to regard the auriferous slates as Palæozoic. But about the year 1864, I had the good fortune to find Mesozoic fossils in the midst of these slates, and thus removed all doubt of their true horizon. These fossils were *Ammonites* in the slates of Placer county near Colfax; *Belemnites* and Jurassic bivalves in similar slates on the Mariposa estate, Mariposa county, and contiguous to the great gold quartz vein known as the Mother vein of California. Thus the Secondary age of the chief gold bearing slates of California was established.

It is in this great belt of Jurasso-Triassic, and perhaps in part Lower Cretaceous strata, lying enfolded in the western flanks of the great mountain mass of the Sierra Nevada, we find the strongest, richest, and the most productive gold quartz mines and placer deposits of California. The Mother vein at Carson hill, in Calaveras county, has yielded some of the heaviest masses of gold ever taken from veins. Further, one of the deepest gold mines of the world is in the midst of the same great belt of Mesozoic slates.

The occurrence of gold in California is, however, not confined to any one geological horizon. It is found in close contiguity to limestone of Carboniferous age, as early shown by Dr. Trask, and no doubt in the older rocks of the Sierra Nevada lying parallel with the chief auriferous deposits. Thus at Hite's cove, some miles west of the locality of the Jura-Trias fossils of Mariposa, there is an important gold-bearing vein near a stratum of limestone in which I have found encrinal stems, and which is no doubt Upper Palæozoic. But these older strata in California have

never yielded gold so generally and in such profusion as the newer beds further west of them. I would not, however, be understood as claiming that the Mesozoic formations, even in California, give as a rule richer mines than any other formation. So far as the evidence goes, for that region, such a generalization might be accepted, but we know far too little of the laws of the formation and distribution of the noble metals to make any rigid discrimination in favor of one geological horizon over any other. Some of the most valuable gold mines do not occur in stratiform rocks. The celebrated veins of Grass valley, California, which have been worked continuously for over forty years are in crystalline granitic rocks of uncertain age. The great Comstock lode in Nevada, which has added so many millions to the world's supply of gold as well as silver, is in crystalline rocks which, however, are probably altered Mesozoic beds. The gold of the Deep Creek region, Utah, as I have elsewhere shown, is in altered Carboniferous limestone, thus being in upper rather than lower Palæozoic.

The best example we have of gold in the oldest rocks is found in the Black Hills of South Dakota in pre-Silurian strata, probably the equivalents of the Cambrian, Montalban, or still older sediments. But here in these ancient strata, although the aggregate quantity of gold is large, the quantity per ton of rock is not. To use the technical phrase it is "low grade rock" as compared with the gold quartz rock of the California Mesozoic.

The financial success of any gold mining operation is not to be taken as an indication or measure of quantity. Success or failure depends largely upon location, the facilities for working and upon intelligent common sense management.

In conclusion it is well to note briefly the general absence of gold, so far as yet known, in the ordinary red beds of the Trias of the Rocky mountains, and Appalachians, and from all formations where the iron is in the condition of sesqui-oxide. I do not, of course, refer to, or include the oxidized outcrops of formations where at water level the normal condition of the contained iron is that of prot-oxide or of its sulphur compounds. This is the normal state of the California Mesozoic. The auriferous formations there are generally bluish-green and black in color, the diffused iron is in the state of protoxide, or the sulphide, and the formations bear no resemblance to the Trias of the Rocky mountain region or of the Appalachians.

THE CRETACEOUS COVERING OF THE TEXAS PALÆOZOIC.*

RALPH S. TARR, Cambridge, Mass.

The question as to whether the central Palæozoic and pre-Palæozoic region of Texas was completely covered by the Cretaceous, is still a mooted question. Prof. R. T. Hill has at various times stated that this was the case, giving numerous reasons for the statement; but Dr. T. B. Comstock, who, by his detailed study of the central mineral region of Texas, is well qualified to speak upon the subject from other points of view, has come to the opposite conclusion. In the second annual report of the Texas geological survey he has again stated this conclusion, giving therefor numerous reasons of considerable value.

A study of the region immediately north of this area has convinced me of the accuracy of Prof. Hill's conclusion, and it is my purpose at this time to place the reasons for this conclusion on record.

The beginning of the Carboniferous epoch found the central region of Texas a land area considerably denuded. This is proved by the bays and promontories now being uncovered by the erosion of the overlying Carboniferous. It was probably a mountainous area, a part of a much more extensive system now buried beneath later deposits. More than 8,000 feet of Carboniferous rocks were laid down and the sediments forming these rocks came in large measure from the central region or from its extension now buried. This is proved by the conglomerate pebbles in the Carboniferous. In later Carboniferous times, during the deposition of the Coleman beds, the Carboniferous of earlier date had been added as a coastal strip to the older land. The general absence of conglomerate and sandstone in these rocks is proof of this, and the presence of numerous shore lines in the Coleman beds points to the same conclusion. The extensive Permian rocks of central western Texas are in the main inland sea deposits, and during this time the Palæozoic was still land. From the close of the Permian to the beginning of the Cretaceous we have no definite evidence from the Texas deposits, so far as they have been studied, though there can be little doubt that the older Palæozoic rocks remained dry land.

Thus, from the beginning of Carboniferous times, and earlier,

*Published by permission of Mr. E. T. Dumble, State Geologist of Texas.

until the Cretaceous period, with the possible exception of early Carboniferous times, the ancient Palaeozoic core of Texas has been subjected to denudation. Since the beginning of the Carboniferous to the present, along the northern border of this area, there have been no disturbances of sufficient moment to affect the Carboniferous rocks, barring only the gentle tilting to which these have been subjected. In other parts of the area this is not true, for Dr. Comstock finds later disturbances, and the post-Carboniferous age of the Burnet granite has been quite definitely settled. The point intended to be made here is, that the older rocks have not been subjected to extensive mountain building forces in post Carboniferous times, otherwise it would be difficult to understand the remarkably unbroken nature of the Carboniferous rocks which skirt its northern border. Post-Cretaceous disturbances to the southeast, such as that of the Burnet granite intrusion do not, of course, enter the problem under consideration.

So, from Carboniferous to Cretaceous times the area was not only one of continuous denudation, but also one free from the rejuvenating effect of extensive elevation. How greatly denuded this area was in pre-Carboniferous times cannot be stated with absolute certainty, yet the valleys and promontories buried beneath the Carboniferous are not sharp and deep in topographic outline, but, rather, rounded, as if of adolescent or mature forms. This seems to show that the area, though a mountainous area, was not at that time one of striking relief. From that time to the beginning of the Cretaceous its relief must have been greatly reduced in the absence of distinct rejuvenation. Yet, as will be shown, it was at this time a land of considerable topographic diversity.

The lowermost Cretaceous bed is a hodge-podge of sand and conglomerate representing in large measure the old land, in part, if not entirely, worked over by the sea as it advanced upon the Palæozoic land, which was sinking beneath the ocean. Stratigraphically this, the Trinity of Hill, is the lowest member of the nearly horizontal Cretaceous; but it may represent a wide period of time, for, in places it is found on the Palæozoic land at an elevation of 1,250 feet above sea level, while at other places it rests at an elevation of 1,900 feet. Thus this vertical difference of 650 feet means approximately the time required for the land to sink 650 feet; and that there is this amount of difference of time

in the deposition of the Trinity sands in these two places. In order to eliminate a possible error, even in this calculation, arising from the complication involved by the tilting of the entire area in post-Cretaceous times, it may be well to take differences of elevation in a northeast and southwest direction, which will reduce the difference in elevation from 650 feet to 500 feet. The difference calculated here is based upon points fifty miles apart. That this difference is not great, when compared with the time of formation of the series as a whole, is proved by the fact that immediately over the Trinity, in every place, is found the lower layers of the Comanche Peak beds. Thus it seems likely that the submergence of the land was tolerably rapid. This is still further indicated by the unassorted arrangement of the lower beds and their wide diversity.

That the Carboniferous land was a level land, is proved, on every hand, by the fact that, on the Carboniferous proper, there are no excessive changes in the general level of the Trinity beds; but, that the Carboniferous was a land area, and one of gently undulating surface, is equally well proved by the gradual changes in elevation in the different parts of the region now partially covered by Cretaceous. For instance, southwest of Brumwood, on the west side of Pecan bayou, in five miles, on a north and south line, the elevation changes from 1,350 feet to 1,500 feet, or an increase of 150 feet going northward five miles. The Santa Anna, Cretaceous butte, in Coleman county, rests in Carboniferous at an elevation of about 1,750 feet while fifteen miles to the northwest the Cretaceous-Carboniferous contact is at an elevation of 2,100 feet. At the base of the scarp along the Colorado river, the lowest Cretaceous boundary is a gently undulating line with a general rise to the north. The hills recently uncovered from beneath the Cretaceous are broad, flat-topped, and gently undulating. The gradual rise to the northwest is probably to be accounted for by the tilting of the entire mass in post-Cretaceous times; and it is probable that the old-land slope has been reversed by this means.

From this it will be seen that there are no places where the position of the lower Cretaceous seems to indicate any sharp erosion or striking topographic relief in the Carboniferous land; but in the bordering Silurian the case is different. This was the highland of the time and, as would naturally be expected, the

hard rocks of that formation resisted the base-leveling process long after the softer rocks of the Carboniferous had been reduced to it. The Harper knobs west of the San Saba consist of Trinity conglomerate resting on Carboniferous at an elevation of 1.400 feet. Within five miles in a southeast direction there is Silurian. at present 1.650 feet high without any Cretaceous covering. Within seven miles in nearly the same direction, there is a Silurian hill without Cretaceous, at an elevation of 1,850 feet. That is, in seven miles, there is a rise of 450 feet *at least* in the pre-Cretaceous topography. There are many other places where the Silurian rises to this elevation without any sign of ever having had any Cretaceous covering; but, southwest of Brady, Cretaceous is found resting on both Carboniferous and Silurian at an elevation of 1,900 feet. Here the Trinity rests at an elevation of 150 feet above the nearest Cretaceous on the Upper Carboniferous, 10 miles northeast. The significance of this, with relation to the chief point under consideration, will be referred to later on.

From the above it will be seen that when the Cretaceous period began, in Texas, it found a low-lying land of Carboniferous strata undulating and nearly base-leveled, and an older Palaeozoic highland district considerably diversified, but probably not strikingly mountainous. Upon this area the encroaching sea commenced the deposition of the Trinity sands and conglomerates, then, with more complete submergence, followed the higher beds of deeper water origin. A few words upon this peculiar formation will help us in the proper presentation of this argument.

The basal beds of the Cretaceous are revealed in the Palæozoic region along the base of the retreating scarp from beneath which the Carboniferous and other beds are being uncovered, and also along the base of the buttes and patches of Cretaceous which remain as uneroded remnants on this area. Being nearly horizontal they are revealed over a great area by this means. Along the eastern margin in the Colorado river escarpment the beds are conglomerate, in the main, and vary in thickness from twenty feet or less to one hundred feet. Farther to the west the basal beds are sands instead of conglomerates, and there are also shales and impure limestones. Over the Permian these beds are red in color from the color of the underlying rocks.

In lithologic character the conglomerate is quite remarkable, being often composed of large pebbles with a chalky cement.

The pebbles are frequently well rounded, and are sometimes, as for instance, south of Milburn, fully one and one-half feet in diameter. They are almost exclusively of flint and marble from the Silurian.

I am not able to account satisfactorily for such a conglomerate. At first I was inclined to the belief that it represented old river beds, and I am not certain that this will not be found to be the origin of some of these conglomerates. The rather linear arrangement, in places, the fact that many miles away from the Silurian large pebbles from this source are found, and the presence of silicified wood and land fossils seem to indicate this origin. The close resemblance which some of this conglomerate bears to quaternary conglomerates in the creek beds is very striking. In Wallace creek, west of San Saba, the pebbles brought from the Silurian in times of flood, are cemented by a tufaceous matrix, deposited from chemical solution by the evaporation of the water, and this conglomerate resembles the Cretaceous so closely that several good observers have at first sight considered hand specimens of the two the same.

Certainly this is not an ordinary beach conglomerate, for, in addition to being composed of large and sometimes well rounded pebbles, it is composed, in fully one-half its bulk, of a matrix of limy matter. We have a basis for comparison in the same field, for, near Rochelle, Cretaceous conglomerate rests directly on the Carboniferous conglomerate. Not only is there no resemblance between the two in the character of the matrix, but the pebbles also, though derived from the same source in both cases, are entirely different. The Carboniferous conglomerate has no pebbles of marble, but the Cretaceous contains very many marble pebbles in addition to the flint derived from the marble. This comparison shows that, while the Carboniferous conglomerate had been subjected to much sea-shore grinding, the Cretaceous was almost free from such action.

It can be readily shown by subtracting the present slope of the old Carboniferous land from the dip of the Cretaceous that the dip of the old pre-Cretaceous land was several feet per mile to the northwest. Consequently as the land sunk beneath the sea the water encroached from the west toward the east.

The Trinity beds are probably nothing more than hurriedly worked over soils and land debris, in a rapidly encroaching sea,

the rapidity being indicated both by the character of the strata and the fact that at points four or five hundred feet above one another the same stratum is found. The encroachment being from west to east, as it proceeded, a bed of varying character and thickness was formed according as topography and amount and character of supply varied. Such being the case it follows that at a distance from the elevated Silurian land the soils upon the comparatively level and rather soft Permian rocks furnished red sands, and, upon the Carboniferous, a yellow sand; but near and on the Silurian the stream beds supplied the waves with coarse material. This conglomerate hurriedly worked over and not much altered, soon came beneath the reach of wave action, as the subsidence of the land continued, and there became mixed with and covered by the finer deposits washed from the succeeding shore lines. In the quite rapid subsidence it is possible that some protected river deposits may have escaped destruction, but I know of no instances which can definitely be stated to be of this origin.

Above these beds everywhere are found deposits of great uniformity free from conglomerates, and usually free from sandy material. Certain of these beds are stated by Prof. Hill to be of truly deep sea origin, indicating a subsidence of several thousand feet. The remarkable extension of certain thin beds over hundreds of square miles proves great uniformity of conditions attending their deposition. A great thickness of true chalk is also proved by him. The aggregate thickness of these deposits is several thousand feet.

If I understand Dr. Comstock aright he conceives the Silurian to have been an island in this sea, for there can be no doubt that the Cretaceous extended well up to the present limits of the area, since the Cretaceous still exists there either in remnants or as an escarpment to the main Cretaceous area. This Palæozoic island at present seldom reaches much above 2,000 feet, and is usually much less. At an elevation of 1,900 feet southwest of Brady, as already stated, I have found Trinity beds with distinctive Trinity fossils as identified by Prof. Hill, and at present in the collections of the Texas geological survey. With the present topography this would submerge the greater part of the older Palæozoic beneath the Trinity sea. That still greater subsidence went on in the main Cretaceous is proved by the accumulation of

several thousand feet of strata above the Trinity, some of them of deep water origin.

If, instead of being a moderately low lying highland, as I have attempted to prove, the central mineral district was a mountainous area of great hight and topographical diversity, it might still be an island in the Cretaceous sea. This seems more unlikely, however, when we consider the comparatively small area of the district, or, at least, that part of it which cannot be proved to have been covered by Cretaceous by the existence of remnants of these strata: however, the continuation of this area along the Pedernales river, and probably elsewhere beneath the Cretaceous, shows that large parts of the older Palæozoic rocks had by this time lost their former topographic diversity, and become reduced to highlands of moderate elevation and topography. In view of these facts it would be quite remarkable to find a single small area retaining its elevation to a sufficient degree to withstand the long continued and deep submergence of Cretaceous times and still remain an island.

Aside from these facts there is another bit of evidence pointing to the same conclusion. With the exception of the lower Trinity beds the Cretaceous is quite without evidence, where I have seen it, of neighboring land. In the chalk and other beds the material is of such extreme purity that the neighborhood of land is quite out of the question, without the assumption of intermediate currents of sufficient rapidity to remove all land debris of even the finest quality.

Dr. Comstock puts forward* several reasons for his belief which I wish briefly to consider. First, the absence of remnants of Cretaceous on the older Palæozoic is noted. This is certainly striking, but it may equally well prove that the Cretaceous has been for a long time removed from this area, as I shall attempt to show possible. Upon the Carboniferous, low lying and undiversified as it is, there are areas of considerable extent, only recently uncovered from beneath the conglomerate, in which, except in the stream beds, no signs of this covering exist. In the strongly diversified older rocks, with their greater elevation, this removal would be much more quickly and completely accomplished.

Secondly. "The Cretaceous beds along the borders, even including the fossiliferous limestones, in large degree, are chiefly

*Second Ann. Rep. Texas Geol. Survey, 1891, pp. 663-4.

shore line deposits of local origin." If these beds are Trinity or lower Comanche limestones it merely proves that at this time the older rocks were not completely submerged; but if they belong to the higher beds the argument is quite unanswerable.

Thirdly. The irregularity in dip of the Cretaceous is mentioned. This is not the case in the more northern region which I have studied. This irregularity in dip may have been due to original irregularities of the old land surface or to subsequent deformations which Dr. Comstock himself has proved to have occurred in the region under consideration.

The fourth and fifth arguments refer to the effects of faults in the older rocks, the meaning of which I cannot quite make out from the brief statement which he was obliged to make. Having no knowledge of the region in question or the phenomena referred to, I should not feel myself qualified to answer these arguments.

The sixth argument is the vast erosion shown in the older rocks, far too great to have been accomplished in post-Cretaceous times. This is precisely the ground that I have taken above in attempting to show that the central core has been subjected to denudation from before Carboniferous times to the beginning of the Cretaceous

Dr. Comstock's seventh argument is that the pre-Cretaceous topography is still being perfected, the present streams occupying the old valleys, quite in contrast to that which is seen in the area only recently uncovered from beneath the Cretaceous. A stream superimposed upon a lower rock through an unconformable covering finds itself following an irregular course, with little regard to revealed topography and structure. It is now pretty well proved that the streams will eventually adjust themselves to the newly formed topography. I have attempted to show, in articles in the *American Journal of Science*, that this has been the case in the Carboniferous area of central Texas. Where recently uncovered the streams flow over the Carboniferous in very irregular courses, but, as you proceed away from such places, they are found more and more in conformity with the Carboniferous structure. The tributaries to the Colorado, and that river itself, show such adjustments. In a region like the older Palæozoic which is so much more diversified in topography and structure, so much more elevated and, probably, so much longer uncovered, this process of adjustment has had both more time and opportunity for

expressing itself. In this way the correspondence of present and ancient valleys may be accounted for even though the entire region was once completely buried beneath Cretaceous strata.

The eighth and last argument is in no essential particular different from the first, and therefore requires no separate answer. With the exception of two of Dr. Comstock's arguments, other explanations seem possible, and these explanations do not militate against the theory that the entire Palæozoic and older rocks were once buried beneath the Cretaceous. The weight of the other two arguments I cannot attempt to decide upon.

Granting that the Cretaceous at one time extended completely across the Palæozoic and Archean, it remains to be shown how it happens that this area contains now no relic of this former covering, whereas the Carboniferous abounds in such evidence. The reason for this cannot be stated definitely, although there are several possible explanations. In the first place the Cretaceous, owing to the elevated nature of the Palæozoic core, may have been actually thinner here than elsewhere, and hence more quickly cut through. Another possible explanation is that the post-Cretaceous deformations noted by Dr. Comstock may have elevated these regions above sea level earlier than the neighboring regions, and thus given them a long start in the race of denudation. A more reasonable explanation than these even exists in the probable form of the Cretaceous sea floor. The central highland region of Texas, is at present much more elevated than the uppermost Cretaceous beds to the southeast. Even the accumulation of several thousand feet of sediment could hardly be expected to completely efface this old mountain area. It most probably formed a great dune in the Cretaceous sea, which, in post-Cretaceous times was the first to be raised above the sea, and consequently the first to be attacked by erosive agents. That the elevation of the Cretaceous was in great measure continental in character is shown by the uniformity in dip throughout the Cretaceous area. It seems probable, therefore, that if, as is supposed, the central district was submerged and covered, it was the first to appear, and this fact will account for the quite complete removal of Cretaceous, and the adjusted courses of the streams.

In summary it may be said that it has been the attempt of this paper to prove that the central Palæozoic and pre-Palæozoic core of Texas has been from before the beginning of Carboniferous to

Cretaceous times, almost, if not quite uninterruptedly a land area subjected to denudation; that, at the beginning of Carboniferous times the land was already eroded beyond the stages of youth nearly to topographic maturity; that, when the Cretaceous period began, it found the Carboniferous area a low-lying base-levelled area, a peneplain skirting a moderately low and not strikingly diversified highland of older and harder rocks; and that the Cretaceous ocean completely covered this region, depositing thereon a considerable thickness of Cretaceous rocks. The encroachment of the Cretaceous sea was rapid as is indicated by the peculiar Trinity conglomerate, which is apparently hurriedly worked over land debris. The final chapter in the history was the post-Cretaceous elevation, which first raised this region above the sea, because its former elevation was in part indicated in the topography of the Cretaceous ocean even through the blanket of Cretaceous strata which covered it. Being the first to be raised above the sea it was the first to be eroded, and consequently now, over large areas, shows no signs of the former covering, either in remnants, Quaternary debris, or in unadjusted stream courses.

NOTES UPON NEBRASKA TERTIARY.

By F. W. Russell, Chicago, Ill.

In the January (1890) number of the Geologist the writer presented some preliminary observations upon certain geologic formations of central Nebraska. Obtaining many of these data from reconnaissance a desired degree of accuracy could not be attained. Subsequent examination has served to reveal more completely certain criteria for the study of this central record. One hiatus is closing but we can not, as yet, proceed along an unbroken sequence. Most noticeable does this become when we endeavor to intercalate certain beds between the inferior Tertiary limestone and the superior loessian formation. These beds, as far as seen, do not contain data for exact horizonal determination. The problem then resolves itself into placing them from their relations to the other formations. Briefly then to get the sequence in mind let us consider our material. We shall find at the base the unquestioned Tertiary buttes. The writer has examined all the

outcrops occurring in the counties of Sherman, Howard, Greeley and Valley. Two of these Tertiary exposures have been previously cited viz: at Scotia and Seneca, in Hooker Co. I will give two more, one at Brewster, one at Rockville. With the exception of the last the masses rise in isolated buttes from 65 to 100 feet. Rockville exposes only a few feet.

In composition there is but little difference. Seneca, Scotia and Brewster almost the same; Rockville slightly more siliceous. Among the observed fossils *Planorbis, Physa, Limnæa, Viviparus* identifiable. Also many fragments that cannot be recognized even generically. The Seneca outcrop alone has furnished vertebrate remains.

Passing upward to the superimposed and unconformable sands, clays, gravels and loessian we find these clearly differentiable into two divisions. The sands, clays and gravels comprise the beds to be inserted between the other known terms. The best locations for examination and study are along lines of the Burlington and Missouri River railroad in the aforementioned counties. The extremes of variation are a pronounced ferruginous arenaceous mass and a drabbish argillaceous soil. The typical component is an iron stained clay. The ferrugineity is often manifested in small iron concretions and in hand specimens of iron-cemented sand. Not infrequently do these hand specimens show the presence of manganese. This particularly from a deposit south from Arcadia in Valley Co. Digestion with hot hydro-chloric acid demonstrates protoxide of iron as an external granular deposit on much of the sand. After such treatment the dark grains came out surprisingly white and clear.

Contrasting the individual particles of this formation with the superior and non-conformable loessian distinct differences obtain. In the lower material the percentum above .028 mm. is much greater. The grains do not show such marks of attrition. The percent of water-worn particles is somewhat high but even here the original angular faces have not been removed. Of the particles, most are quartz, but identifiable I find muscovite, biotite, hornblende and glauconite the most common. Of hand specimens syenite, quartzite, chert, quartz and granite. The last however of very limited occurrence.

As far as observed this horizon is destitute of fossils. Hence present examination must proceed without these valuable indices.

Continued study and search may result in bringing organic remains to light. Let us hope.

The natural outcrops of this formation are rare. In places the creeks of the bluffs have cut through the superincumbent loessian and thus revealed the clays and sands. This rarity of natural outcrop is not strange when we think of the extent and thickness of the loessian blanket. But where revealed, whether by creek erosion or railroad cutting, there is exhibited always a non-conformity. Not abrupt, as upon the Tertiary buttes, but having more undulation, as though the beds sank quietly below the water and received a uniform precipitation. However, such a deposition of sediment as did not effectually conceal the previous contour. Upon the emergence of the land the drainage at once assumed almost the identical conditions that had previously obtained, and in many places we find streams running on loessian beds in channels marked out for them prior to the deposition of this formation. The Loups are not rapid eroders, on account of the load of sediment they carry. They have not hence cut through the loessian blanket.

In the lower of these two divisions above the Tertiary buttes we have no vertical cleavage. In this respect it differs pronouncedly from the formation immediately above. The common calcium carbonate nodules are also wanting. In summation, then, the cardinal characteristics for recognition are the presence of iron and the iron stain; the presence of gravel, some particles being quite coarse; absence of fossils; absence of calcium carbonate, both in nodules and disseminated; absence of vertical cleavage, and presence of manganese. The last perhaps rather more local than general. These data obtain for all of the many outcrops thus far examined in the counties of Valley, Greeley, Howard and Sherman.

Turning to the superincumbent deposit then, let us still further note the differences. This formation has a uniform buffish to drabbish appearance. The particles are smaller and more uniform, showing greater attrition. Calcium carbonate present in nodules and disseminated throughout the mass. Vertical cleavage always found, and becomes one of the most important means of identification. The formation is fossiliferous, having such forms as *Succinea*, *Zonites*, *Helix*, *Pupa*, *Vallonia*, *Helicodiscus*, etc., of which *Helicodiscus* and *Succinea* occur in great numbers.

What, then, are the ages of the formations? Are we justified in assigning the lower buttes to the Miocene? It seems so. The indications point to this conclusion. If we adopt this determination then we may with propriety assign the formation of the bluffs to the Pliocene. The question then arises, is the variation between this upper Pliocene and the beds immediately under greater than might be found in one formation? Considering the variableness of the Tertiary, so great dissimilarity might be found within the one division. In this case the upper bluffs would be the superior member, and the gravels, etc., the inferior member of the Pliocene.

ON FOSSILS IN THE LAFAYETTE FORMATION IN VIRGINIA.*

By N. H. Darton, U. S. Geological Survey, Washington, D. C.

In a paper entitled "Mesozoic and Cenozoic Formations of Eastern Virginia and Maryland,"† I described the relations and distribution of this formation in the western portion of the coastal plain region, and announced its extension northward through northeastern Virginia and Maryland.

During the past season I have found that the formation extends eastward down the coastal plain peninsulas nearly to Chesapeake bay. These peninsulas consist of remnants of an elevated plain, occupied by a sheet of Lafayette formation, and originally continuous over the entire coastal plain. This plane is inclined gently eastward, its altitude decreasing from 300 feet in the Piedmont region, to from 60 to 80 feet in the vicinity of Chesapeake bay, where it is terminated by an abrupt descent to the low Pleistocene terrace bordering the bay to a width of several miles. The great drainage depressions are excavated in this plain and the resulting peninsulas are more or less widely fringed by the low,

*This formation on the Atlantic coastal plain was first described under the name Appomattox, by McGee, in 1889, in a paper entitled "Three Formations of the Middle Atlantic Slope," *Am. Jour. Sci.*, 3d series, vol. 35, pp. 328-330. In the American Geologist, vol. 8, pp. 129-131, Hilgard proposed to revive the term "Lafayette," which was applied in the Mississippi region in 1855-'56, and the term was adopted by McGee and Darton in a chapter on the Geology of Washington in the guide to Washington, prepared for the meeting of the International Congress of Geologists, in August, 1891.

†Geol. Soc. Am. Bul., vol. 1, pp. 431-450, map.

Pleistocene terraces which occupy them. The peninsula remnants of the high plain are also invaded by steep-sided, lateral drainage-ways. The aggregate area of Lafayette formation remaining is, however, more than half of the original amount, and the level, monotonous surface of the old plain is the characteristic feature of all the higher land of eastern Virginia and Maryland.

In its eastward extension the formation gradually becomes finer-grained; the pebbles are small and in less proportion and the amount of argillaceous matter increases. The predominant materials are orange and buff sands, with irregularly distributed drifts and sprinkling of small pebbles. Near the base of the formation in the easternmost localities thin beds of grey clay become conspicuous, but they alternate with beds of sharp sands. The formation gradually thickens, also, and finally a thickness of from forty to sixty feet is attained. Throughout its eastern extension the formation lies unconformably on the east-dipping surface of the Chesapeake (Miocene) sands and its base usually includes more or less Chesapeake materials.

It was hoped when the off-shore deposits were studied that fossils would be found, for no traces of organic life had been discovered in the coarse beds farther westward, and it would be very interesting to know something of the life which existed in this region in Lafayette times. Careful search finally resulted in the discovery of a fossiliferous locality, but the remains throw but little light on the question. They consisted of water-worn shell fragments, and occurred in a thin coarse sand stratum a few feet from the base of the formation, in a road-cut a short mile northeast of Heathsville, the county seat of Northumberland county, Virginia.

The remains were submitted to Dr. W. M. Dall, of the Smithsonian Institution, and to Dr. W. B. Clark, of Johns Hopkins University, but as the material was in such poor condition it was difficult to identify species. The most abundant individuals were *Venus mercenaria*: a Gnathodon was recognized which Dr. Clark thought was probably *G. grayii*, and a badly worn shell suggested *Anomia simplex* to Dr. Dall, but he was very doubtful as to its identity.

The *Venus mercenaria* has such a wide range as to be of no service in the present inquiry. *Gnathodon grayii* is a Miocene form, but other Gnathodons occur in the Pliocene, and the genus is still living in the seas of the far south.

Owing to their proximity to the Chesapeake formation, and the broken and water-worn condition of the shells it is possible, if not probable, that they were derived from the underlying formation. The soft, loose Chesapeake sands at this locality were never richly fossiliferous and have lost their shells by solution, but there are other localities, not far from Heathsville, where both Venus mercenaria, Gnathodon and other Miocene shells occur in abundance in the Chesapeake formation.

QUATERNARY GEOLOGY OF KEOKUK, IOWA, WITH NOTES ON THE UNDERLYING ROCK STRUCTURE.

By C. H. Gordon, Evanston, Ill.

While the Keokuk limestone with its very interesting piscine and crinoidal fauna, and the shales with their peculiar siliceous deposits, have made this locality widely noted, the special topographical and stratigraphical features of the region have received comparatively little attention. We have noted already some of the important features pertaining to the lithified deposits*, and it is the purpose of this paper to consider the equally significant topographical and Quaternary features.

Keokuk is situated in Lee county, which comprises the triangular area at the junction of the Mississippi and Des Moines rivers, in a bend of the Mississippi about two miles above its confluence with the Des Moines. For a distance of eight miles above the city, the general course of the river is due south with a slight bend to the west. Opposite Main street it makes a sharp turn to the west, bearing off s. w. by w. for nearly three miles, where it is joined by the Des Moines and again resumes its southerly course. From Montrose, nine miles above, the river flows over the cherty layers at the junction of the Burlington and Keokuk beds, giving rise to what is known as the Des Moines rapids. The canal along the western bank, constructed and maintained by the government to overcome this impediment to navigation, constitutes one of the important engineering features of the river. Just below the lower lock, an iron bridge spans the river, connecting the city with Hamilton, a thriving village on the Illinois side; while a few

*American Geologist, Oct., 1889, p. 237; same, May, 1890, p. 257; American Naturalist, April, 1890, p. 305; American Journal of Science, Oct., 1890, p. 295.

miles below, and easily seen from the hights at Keokuk, are Warsaw on the Illinois side, and Alexandria in Missouri. The former is of interest as being the home of A. H. Worthen, whose labors as state geologist of Illinois placed him in the foremost rank of scientists. The name, Gate City, was applied to Keokuk in the old days of prosperous river traffic, when its position at the head of navigation made it the "entering port" of much of Iowa's commerce.

Topography.—The thickness of the surface deposits is not such as to materially affect the topographical features of the region, and hence these derive their significance largely from the subjacent rock surface. A high mural escarpment faces the river along the eastern and southern sides. In places this wall is considerably reduced and toward the south is intersected by the narrow valley of Soap creek, leading in from the northwest. Near the lower lock, the escarpment rises in bold outlines, with retreating summit, to a hight of one hundred and sixty feet. Farther to the north, the bluff presents a steeply sloping face covered with superficial deposits. On the south, the escarpment is bold and conspicuous, rising to a hight of nearly two hundred feet, its face irregularly scalloped by narrow and short ravines. The highest points at the north and south are capped, underneath the Quaternary, by Coal Measure deposits, while between these points varying portions of the underlying rock have been removed by pre-glacial erosion. Patches of the St. Louis beds still crown the bluff at places north of Main street, while at its foot, erosion has extended to the Geode formation of the Keokuk beds. A drainage basin occupies the interior of the city north of Soap creek, and opens into the valley of that stream a little above its mouth. In this area the rocks above the Geode formation have been largely removed, leaving an amphitheatre-like depression, partially filled by subsequent deposits. These have suffered considerable denudation, however, since the time of their deposition. Toward the northwest, the surface gradually rises to the narrow undulatory plateau forming the divide between the drainage systems of the Mississippi and Des Moines rivers, and broadly scalloped on either side by subsidiary drainage basins. At Montrose, the bluff recedes from the river, leaving a belt of high bottoms three or four miles wide between this point and Fort Madison above. Beds of sand and gravel are here found twenty to thirty feet above the present high-water level of the river. Between this point

and Keokuk, a band of water-worn shells of the same species as those now living in the river (Uniones) extends along both sides of the river at an altitude of fifteen to twenty feet above present high water mark.* There are indications that between these points the channel of the river in pre-glacial times was west of where it is now.

Rock Series.—The following is an approximately complete section of the rock series as now known here.†

I. ROCK SECTION AT KEOKUK, IOWA.

			Thick.	Depth.
LOWER COAL MEASURES.	1.	Sandstone with *Stigmaria*, exposed	10"	
	2.	Black fissile shale	6'	
	3.	Coal	1'-6"	8'-4"
	4.	Fire clay	3" to 6"	
	5.	Black shale	11'	20'
	6.	Sandstone with *Stigmaria*; rests upon the uneven surface of the St. Louis limestone. Lower portions include limestone fragments, and occasionally *Lithostrotion canadense*	10' to 20'	36'
ST. LOUIS.	7.	*Upper.* Brecciated limestone. Stratification irregular. Portions abounding in greenish and gray clay. Limestone fragments 5 to 12 inches in diameter, and more or less water-worn. Fossils usually in fragmentary condition. *L. canadense*	8' to 20'	50'
	8.	*Middle.* Light or bluish-gray sandstone. Calcareous above, more or less massive grit below	5' to 10'	58'
	9.	*Lower.* Yellowish-gray or brown magnesian limestone. *Archimedes wortheni*	12'	70'
KEOKUK.‡	10.	*Upper or Geode Formation.* Shales more or less calcareous, with occasional limestone layers. Filled with geodes	50' to 60'	110'
	11.	*Lower, or Limestone Formation.* Layers variable, with one to six inch clay partings. Argillaceous below	60' to 65'	170'

*Worthen refers to this as marking the low water level of the river at some previous period of its existence. Geological Report, Iowa (1858), vol. I, Part 1, p. 186.

†The exposures here comprise all the beds to the base of the Keokuk, including six to ten feet of the underlying transitional chert beds now classed with the Burlington. The remainder of the section was derived from the records of the Hubinger artesian well kept by the writer and published in the AMERICAN GEOLOGIST for October, 1889, p. 237.

‡For a fuller description of these beds see American Journal of Science, Oct., 1890, p. 295.

BURLINGTON.	12. *Upper.* Chert formation ....80′		250′
	13. *Lower.* Limestone.................40′		290′
	Calcareous shale..............65′		355′
KINDERHOOK.	14. Limestone ....10′		365′
	15. Shale...............................195′		560′
HAMILTON.	16. Limestone (shaly)...............65′		625′
ORISKANY.	17. Sandstone (water) ....20′		645′
NIAGARA.	18. Limestone ("sandy").............55′		700′
	19. Sandstone (water).................37′		737′
HUDSON RIVER.	20. Cincinnati (Maquoketa) shale....63′		800′
GALENA AND TRENTON.	21. Limestone, "sandy" below.......140′		940′
LOWER MAGNESIAN OR OZARK.	22. St. Peter's sandstone.............110′		1050′
	23. Alternating limestones and sandstones (water)......................735′		1805′

Till.—The drift covering this part of the state belongs to the first glacial epoch. It is denominated the lower till and constitutes the attenuated border of the drift region. It gradually diminishes toward the south and disappears in the vicinity of St. Louis. The following section was obtained at the foot of Exchange street on the bluff overlooking the river:

SECTION II.

4.	Boulders, gravel and sand commingled. Boulders and gravel predominating. All more or less cemented together by calcareous material. Boulders from 8 to 10 inches in diameter..................................	6 feet
3.	Boulders, clay, gravel, and sand in irregular patches. Same as No. 4, but boulders larger, frequently from 2 to 6 feet in diameter..................................	13 feet
2.	Blue clay, gravel and sand..............................	1 to 8 feet
1.	Shales of the Geode formation.	13 feet

At the foot of Bank street, one block south, No. 3 was seen in contact with the Geode shales. In this division erratic boulders predominate, while above in No. 4 limestones are numerous and apparently but little removed from their original locality. Fragments of the St. Louis, Keokuk and Burlington limestones were observed. Some of the boulders were greatly exfoliated and decomposed. This, together with their cemented condition, has been adduced by Chamberlin and Salisbury as evidence of the early origin of the border till.* No striated boulders were ob-

*U. S. Geol. Surv., 6th An. Rep., p. 264.

served. This may be accounted for by the exfoliation which they have suffered. Moreover, those rocks which have suffered little from this cause, were probably borne along within or upon the ice. Mr. Guthrie has shown* that boulders thus inclosed are constantly rolling upward in the same manner that the coarse material in roily water is whirled upward and outward to be deposited along the banks, or transported to some quiet resting place.

Loess.—A cutting at the corner of Second and Des Moines streets not far from the above locality, discloses the following arrangement:

SECTION III.

7.	Fine, dark drab or ash-colored material, becoming coarser below, and gradating into No. 6...................... ...	8 feet
6.	Coarse red sand, mingled with finer particles; approaches a red clay in places.....................................	10 feet
5.	Fine white sand, interstratified with hard red iron oxide bands from 1 to 2 inches thick..........................	4 feet
4.	The boulder bed underlying the above shows its relations to the preceding section..............................	?

Ferruginous Zone.—The uppermost division presents the typical characteristics of loess. No. 5 and the lower part of No. 6 are more or less stratified. No. 5 is made up of white quartz grains varying in size from 1 to 4 mm. in diameter, those above 2 mm. predominating. They are more or less rounded in outline, though angular forms are not wanting. The red bands show no variation except in the presence of cementing material in the form of iron oxide. No. 6 differs from No. 5 in the added presence of grains from 4 to 10 mm. in diameter, and an abundance of iron oxide and finer particles. Under the microscope the oxide may be seen coating the sand grains, and in masses, along with the smaller particles, filling the interstices between the coarser grains. A vertical cut through the bed exposes small cavities with hardened walls, partially filled with clean white sand. The same white grains may be obtained from the main mass by dissolving the oxide with hot hydrochloric acid, thus indicating the probable origin of these pockets in a leeching process, due to waters charged with organic acids derived from the decaying vegetation above. Rounded grains are common. The decided coloration is a prominent feature of this bed. Wherever laid bare it is easily traced for long distances. Just above Warsaw, on the Illinois

*Lake Michigan Glacier, p. 11.

side, is an exposure easily recognized from Keokuk several miles away. Pebbles of granite are occasionally found, but are not numerous. Chert fragments are frequent, and often occur in accumulated masses. I have also observed geodes distributed sparingly through the bed. Lime concretions occur in the upper portions. The deposit is mostly coarse and porous, and is sometimes used for molding purposes. This bed has sometimes been considered as representing the more important formation towards the south, called the Orange Sand. Hilgard, who first studied these beds (Orange Sand), regards them as the southern equivalent of the northern drift, considering the materials of the two to be "essentially correspondent," and asserts "that there are but two essential particulars to distinguish it from the beds of the northern drift proper: first the absence or at least great scarcity of erratic rocks proper,' * * * and secondly the great prevalence of limited deposits of ferruginous sandstone or conglomerate. * * In the drift of the northern states the ferruginizing process has played but a subordinate part."* Until quite recently this view has been sustained by nearly all of the geologists† who have written upon the subject, those of Illinois alone dissenting, and insisting upon their pre-Pleistocene character. The latter view has recently been confirmed by investigations in eastern Arkansas under the auspices of the state geological survey. R. E. Call, who has made a special study of the Orange Sand, gravels, and Loess of Crowly's ridge, says that he regards the Tertiary age of these beds as unequivocal.‡ In a contribution to the same report, R. D. Salisbury sustains this opinion from confirmatory evidence gathered along the lower Ohio. Briefly, the reasons adduced by the latter for this disposition of the beds, are as follows:

1. The unconformity which exists between the loess and the underlying gravels and sands.
2. The profound weathering and oxidation which these formations underwent previous to the deposition of the loess.
3. The constitution of the gravels of Crowley's ridge precludes their reference to the Pleistocene.§

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*American Journal of Science, 2nd Ser. No. 123, p. 315.

†Safford, Am. Jour. Sci., 1864, Vol. 37, p. 361.
Dana, J. D., Manual of Geology, p. 548.
Leconte, Elements of Geology, p. 548.
Loughridge, Jackson Purchase Region, Ky. Geol. Surv. 1888.

‡Arkansas Geological Report, Vol. II, 1889, p. 126. §Same, p. 224.

Upon the last point Salisbury's statements are greatly at variance with those of the majority of previous writers, for he says that, in the "hundreds of exposures examined for this especial purpose, *not a single pebble of demonstrably northern origin has ever been found.*" If the correlation of these beds with the Tertiary be accepted, and the evidence presented seems conclusive, it opens anew the question as to what constitutes the southern representative of the drift corresponding to the first episode of the first glacial epoch. This is found by the above writers in the lower division of the loess, above which is a zone of ozidation with traces of an old soil separating it from the later loess above. According to this view, it would seem probable that all the deposits above the till at Keokuk should be referred to the loess, and if the ferruginous zone corresponds to that giving rise to the two-fold division suggested by the above authors, then we have the lower division of the southern loess represented here by the lower till *and the ferruginous division above.* An explanation of this, however, may be found in the peculiar location of Keokuk just within the border of the glacial area. In the retreat of the ice sheet to the north there would be deposited first the material held by the ice, forming the lower till. But, as the edge of the ice receded up the valley, the deposit would gradually change, becoming essentially estuarian in character. Then followed a period of deglaciation during which, probably, oxidation played a prominent part. This constitutes the interglacial episode of the earlier glacial epoch. Then came the closing episode, during which, apparently, estuarian conditions prevailed, and the main body of the loess was deposited. According to Chamberlain and Salisbury this all belongs to the first glacial epoch after which the conditions of loessial deposit no more obtain, and the subsequent history of these regions is one of continued oxidation, erosion and rearrangement.

In studying this formation we have been specially interested to learn if there is any significance in the fact that it is most prominently developed opposite and for some distance above and below the mouth of the Des Moines. In seeking an explanation of the probable source of the material constituting it, the agency of that river must not be overlooked. For a large part of its course it has been cutting its way through the sandstones and shales of the Coal Measures. About one hundred miles above its confluence

with the Mississippi occurs an excessive development of red and variegated sandstone. In the vicinity of "Red Rock," to which it has given name, this bed has a maximum thickness of 150 feet.* The material gathered by the river from this and other rocks in its course must have had some part in determining the character of the deposit forming about its mouth.

The Upper Loess.—The upper portion presents the usual characteristics of typical Loess. A careful examination reveals the presence of quartz grains essentially the same as in the ferruginous portion, but greatly diminished in number. The main mass consists of finely divided particles, rock-flour, varying in size from .01 to .05 mm. in diameter. They show no signs of attrition. A bare trace of iron oxide may sometimes be observed. No fossils were seen though the "lime balls" or "loess-kindchen" held by some to be derived from fossil shells are common.

Evanston, Ill.

EXPLANATION OF PLATE.

Scale (except in figure 4). { Horizontal 1 to 19680. Vertical 1 to 1920.

Fig. 1. Profile section (4½ miles) from west to east, through Keokuk and Hamilton, Ill., crossing the Mississippi in the vicinity of the lower lock of the Des Moines canal.

Fig. 2. Profile section (3½ miles) from southwest to northeast across Keokuk Point, starting from a point midway between the mouth of the river and Des Moines bridge.

Fig. 3. Profile section ¾ mile southeast of No. 2, and parallel with it.

Fig. 4. Profile section on Des Moines from the river to Sixth street.

1, 2, 3, 4 equal 4, 5, 6, 7 of SECTION III., p. 187.

ORIGIN OF THE GRAVEL DEPOSITS BENEATH MUIR GLACIER, ALASKA.

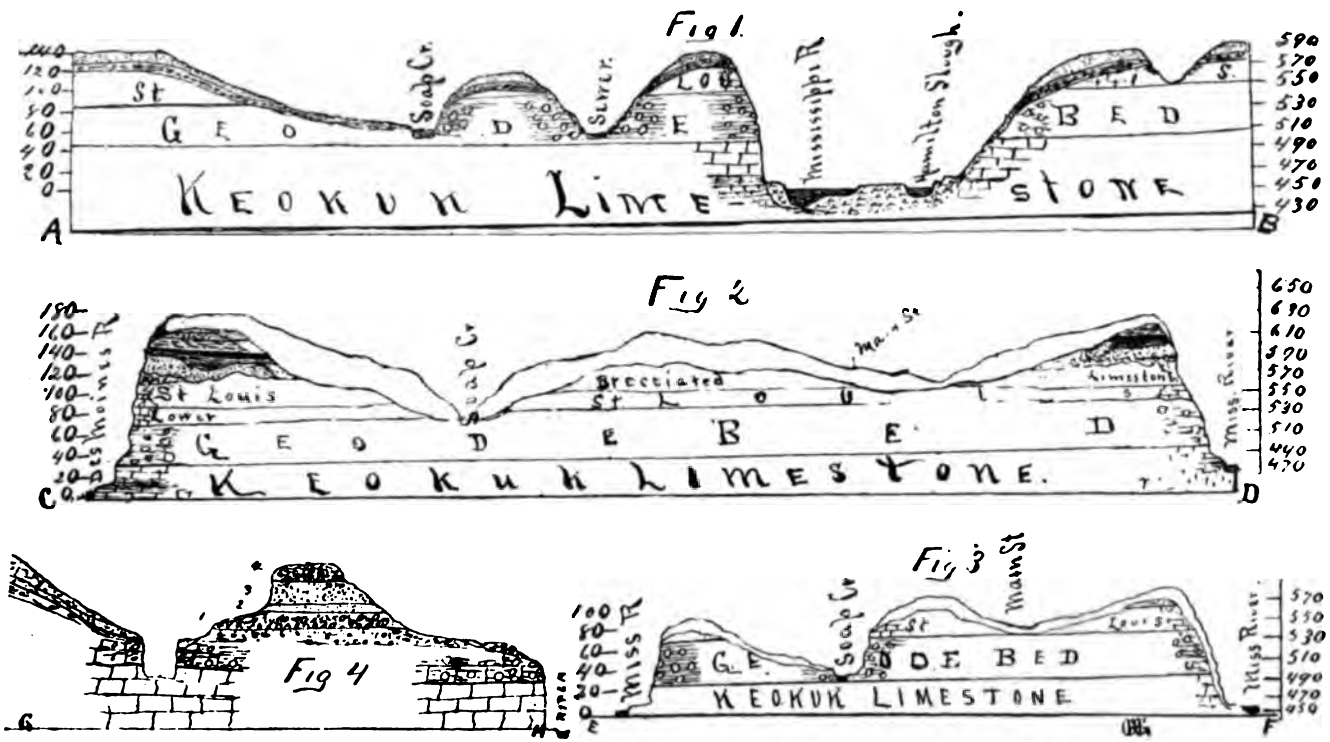
By ISRAEL C. RUSSELL, Washington, D. C.

[With contributions by Prof. G. FREDERICK Wright, Prof. Harry Fielding Reid and Mr. H. P. Cushing.]

In an excellent article on the Muir glacier, in the October number of this journal, Mr. H. P. Cushing described the gravels on which the lower end of the glacier rests, but states that he is unable to explain their origin.†

*Geological Report Iowa (1858), Vol. II, Part 1, p. 168.
Keyes, C. R., Bull. G. S. A., Vol. II, pp. 277-292.

†The same deposits are discussed by G. F. Wright in Ice Age in North America, pp. 57-61; and also in AMERICAN GEOLOGIST, vol. 9, pp. 330-331.



SECTIONS AT KEOKUK, IOWA.

I made a hasty examination of the gravel deposit beneath the ice on the east side of Muir inlet, in 1890, and believe that if I can make clear to my readers how similar accumulations of gravel and sand are now forming in other portions of southern Alaska, we shall be able to come to an agreement as to the history of those under consideration.

The Lesson.

About the outer border of the Malaspina glacier and at the foot of the Atrevida, Black and Lucia glaciers on the west side of Yakutat bay, there are immense "boulder washers," as I have been in the habit of calling them, which are being deposited by over-loaded, glacial streams and have the essential feature of the "alluvial cones" or "alluvial fans," so common in arid regions, except that the material of which they are composed is in general more thoroughly rounded. They are also similar to the subaerial portions of the deltas of high-grade streams.

One of the most characteristic boulder washers observed in Alaska, is on the east side of the Atrevida glacier, and has its apex at a locality where a creek of turbid water, called Esker stream, rushes out from a tunnel at the foot of a precipice of ice about 200 feet high.* The stream flows for two or three miles through a deep gorge, having a moraine-covered bluff of ice for its right wall for a large part of the way, and a precipitous mountain slope, loaded with morainal deposits, for its left wall. The gorge has been formed by the melting back of the ice owing, in a great measure, to the action of the stream which flows through it. Many other sub-glacial streams emerge in a similar manner at the margins of the glaciers mentioned above. Some of these have cut back deep bays or cañon-like recesses in the periphery of the ice; while others have failed to form re-entral angles of this character. Whether or not a local recession of the ice-front shall follow the emergence of a sub-glacial stream, depends on the volume and swiftness of the stream, and on the amount and size of the débris that rests on the ice, and as the ice melts, falls into the stream. When the stream is strong enough to keep its channel open, a deep notch in the ice-front may result; but when the débris from the sides and head of the recession is abundant, and especially when it is of large size, the channel frequently

*An illustration of the source of this creek is given in *National Geographic Magazine*, Vol. 3, 1891, pl. 10.

becomes choked, and the sub-glacial waters are forced to find a new outlet.

In the case of the stream issuing from the Atrevida glacier, the channel is deeply filled with débris, most of it of large size, derived from the ice cliffs near its source, but the water is swift and the boulders are swept along the channel until they can find a resting place. When near the stream, one may hear, even above the roar of the torrent, the clashing and pounding of the boulders as they are rolled along and hit against each other or against the still larger stones over which the water rushes. As soon as the cañon widens, the stream divides and piles up the boulders, now on one side of its channel and now on the other, while the finer material is carried farther down. Owing to the deposition of the coarser portion of the heavy load with which the stream starts, its channel is built up higher than the adjacent surface, and consequently the drainage is unstable. Some three miles from its source the stream passes a spur of hills on its left and has room to expand its deposits. It then bifurcates again and again, and is constantly forming new channels. The region through which the stream flows is heavily timbered and the expansion of the torrent-swept area is accomplished by invading the forest on either side of its course. Where this has occurred recently, the dead trees are still standing, and in some instances even retain their withered foliage; farther out in the gravel deposit they are dead but unbroken; while still farther away, only trunks and stumps project above the barren, stream-swept surface. The débris thus being laid down has the form of a segment of a low cone. The apex of the cone is four or five miles from its base, on Yakutat bay, and has an elevation of some six or eight hundred feet. Its breadth near its base is about two miles. The depth of the deposit cannot be determined, as building is in active progress and dissection has not begun, but judging from the contour of the adjacent surface, is must be several hundred feet in the central portion. The deposit is coarse and sub-angular near the apex of the cone, boulders four feet in diameter being not uncommon, but become finer and finer near its base. The outer portion of the deposit, near Yakutat bay, is composed of gravel and sand. From the mode of its formation and the character of its surface, it is safe to assure that it is cross-stratified throughout and has many abrupt alternations of fine and coarse material.

Trunks and branches of trees are scattered over its surface or imbedded in the superficial layers. Portions of trees probably occur throughout the deposit, and beneath it over large areas, there must be a buried forest. Conditions are easily conceived whereby other forests might become buried above the first.

The débris carried down by the stream is derived almost entirely from the moraines on the glacier from which it flows, and partakes of their heterogeneous character. Examples of all of the rocks bordering the east side of the Atrevida glacier occur in the stream deposit.

Owing to the fact that the stream is overloaded at its source and is depositing in that region, it is evident that the apex of the cone is rising, and, consequently, that it is increasing in thickness throughout. The grade of the stream increases towards its source and will continue to increase as the ice wall from beneath which it flows recedes farther and farther. These conditions, together with the constant bifurcation of the stream as it flows down the cone, thus decreasing its transporting power, make it evident that the cone will continue to grow in all of its dimensions until the glacier which feeds it, both with water and débris, ceases to recede, or until the ratio between water supply and the amount of débris contributed is greatly changed.

Another boulder-wash which is being formed by Kwik stream, at the foot of the Lucia glacier, is several times larger than the one described above, but is of the same type. Many others of less size were observed at the extremities of the secondary glaciers about Disenchantment bay, and about the borders of the Malaspina glacier. These numerous examples seem sufficient to demonstrate that deposits of boulders, gravel and sand of the nature of those noticed above, are dependent on the retreat of the glaciers about which they are formed. Should a glacier, after retreating and depositing an alluvial cone, become stationary, it is evident that the amount of coarse débris contributed to the streams draining it would be greatly decreased. The streams would then be in a condition to erode the deposits previously laid down, and to cut channels through them. Should a glacier then advance, it might override or plough into the deposits about its front, and thus still further assist in their removal.

Owing to the rapid disintegration of rocks under the climatic conditions prevailing in southern Alaska, alluvial cones, more

nearly allied to those of arid regions than are the great boulder-washers just described, occur at the mouths of high-grade gorges which join broad cañons, or valleys, but it is not desirable to consider these at present.

The Application.

From the very clear description of the gravel deposits beneath the Muir glacier given by Mr. Cushing, as well as from my own hasty examination of them, I am inclined to think that they are of the same nature as the boulder washer to which attention has been directed. In describing the gravels beneath Muir glacier Mr. Cushing says:—

"They were deposited by swift currents. The material is all coarse, alternating beds of gravel and sand, the gravel largely predominating, and with little or no admixture of clay. Rapid alternations of horizontal and cross-bedding characterize them. A considerable number of the pebbles in the gravel are derived from the eruptive rocks far to the north. They have their edges rounded but are much more angular than are stones which have suffered attrition in water for any considerable length of time. They have rather the aspect of somewhat water-worn glacial pebbles.*

Other points of close similarity between these gravels and the boulder washes now forming, might be cited from the reports of Cushing and Wright; but it is better, perhaps, that the reader who is interested in this discussion should consult the original descriptions.

If we assume that Muir glacier formerly retreated a few miles above its present terminus, so as to allow forests to occupy the region about the head of Glacier bay, and that from the extremity of the retreating glacier a boulder wash was spread out and invaded the forest, and should the glacier then advance and override the deposit of boulders and gravel, we should have an occurrence similar in every way to what is now found at Muir inlet.

That glaciers of great thickness may overrun unconsolidated gravels, without disturbing them, is no longer open to question. An occurrence of this nature on a much larger scale than at Muir inlet, may be seen along the southern margin of the Malaspina glacier, midway between Icy bay and Point Manby, where the sea had encroached upon the glacier and for about three miles exposed a bluff of ice some three hundred feet high, resting on an

*American Geologist, Vol. 8, p. 219.

undisturbed gravel and boulder deposit. The Quaternary glaciers near Mono lake, California, are known to have done the same thing, as is plainly recorded in the gravel-lined troughs through which they flowed, and which still retain their original contour.

A more careful study of glaciers may show that there is a ratio between the grade of an ice stream and its rate of flow, which determines whether it shall erode or protect its bed, or permit of the accumulation of débris beneath the ice.

The manuscript of this paper was forwarded in turn to Prof. G. Frederick Wright, Prof. Harry Fielding Reid and Mr. H. P. Cushing for criticism and suggestions. Their contributions to the discussion are given below:—

Contribution by Prof. G. Frederick Wright.

Mr. Russell having kindly permitted me to read his paper upon "The Origin of the Gravel Deposits beneath the Muir Glacier, Alaska," and having asked me to add any suggestions which come to my own mind upon the subject, I would say that his explanation of the origin of the phenomena seems to me exceedingly probable, and gives great relief to my mind. One fact which he has not mentioned which I had recorded (see Ice Age, p. 57) seems to agree perfectly with Mr. Russell's observations. On the west side of Muir glacier the gravel deposits which have covered the forests, and which are now in part overridden by the glacier, rise from 100 feet above sea-level at the southern termination of the deposit, to more than 300 feet in the vicinity of the present ice-front, which seems to be exactly in accordance with Mr. Russell's theory.

This explanation furnished by Mr. Russell of the perplexing facts in Muir Inlet illustrates anew the complicated character of the forces in operation during both the advance and the retreat of a great glacier, and shows how competent a glacier is to account for most diverse classes of facts With such a cause in the field, we may well hesitate long before concluding that we have exhausted its capacity or resorting to unknown causes for the explanation of our facts.

Oberlin, Ohio, Nov. 10, 1891.

Contribution by Prof. Harry Fielding Reid.

The explanation given by Mr. Russell of the sand and gravel deposits on the shores of Muir inlet seems perfectly satisfactory. From Mr. Cushing's observations both he and I were convinced that they were formed by running water. The gravels in Main valley and in the valley of the Dying glacier probably have a similar origin; in these cases, however, they sweep quite across the floors of their respective valleys We often questioned whether the deposits on the two shores were ever connected, without finding any evidence pro or con.

The gravels forming these deposits vary in size from sand to pieces as large as one's fist, rarely being much larger; so it is probable that the glacier is now somewhat more extended than when they were laid down, and that the upper end of the cone where larger and more angular rocks would be found, is still under the ice some distance higher up the valley. The highest part of the bluff overlooking the Inlet is about 150 feet above tide, and occurs about where the glacier ended at the time of Prof. Wright's visit in 1886 (see map in "Studies of Muir glacier," shortly to be published in the *National Geographic Magazine.*) According to Mr. Russell's idea they should become higher as we ascend the valley: as a matter of fact they become lower, being almost at water level at the point where the ice-point stood in 1890. Hence if Mr. Russell's explanation is correct, and I think it very probably is, some 150 or 200 feet of gravel has been carried off from this point (and still more higher up the valley) since the former great retreat of the glacier. The angular rocks spread over the surface of these deposits were left there during the present retreat of the ice.

Charpentier was the first one, I think, to notice that glaciers will ride over gravels* It is a mistaken notion that sands and gravels do not form a solid bed. When prevented from yielding laterally, or, what amounts to the same thing, when in large amounts, they offer a remarkably firm support. In soft, marshy lands it is customary to make satisfactory foundations for buildings by driving in piles, withdrawing them, and then filling the holes with sand.

Cleveland, Ohio, Nov. 23d, 1891.

Contribution by Mr. H. P. Cushing.†

I have read your MS. with great interest. It clears up several doubtful points, but I must confess that the main difficulty under which I labored in endeavoring to interpret the phenomena does not seem to be helped. That the deposits were formed by overloaded sub-glacial streams was clear to me. It was not clear, however, and is not yet, how they could be deposited in such a location. A glance at Reid's map accompanying my paper, will indicate what I mean. Muir inlet is narrow and deep, and its shores are precipitous mountain slopes, except for the narrow space occupied by the gravels, which rest on an old forest soil. As stated in my paper, p. 221, suppose the ice to have retreated some few miles back, which is also required in your explanation. As the ice retreated, sea water would follow it, certainly for a considerable distance, leaving merely a narrow sloping shore between the water and the mountain slopes. How a stream could run along such a shore for any distance and build up such a deposit, I cannot conceive. After running at the

*Essai sur les Glaciers, 1841, p. 72, foot note.

†Mr. Cushing's letter was not intended for publication, but permission was granted to use such portions of it as I thought best. The paragraphs given above are all that relate directly to the subject under discussion, and are presented with a few slight verbal changes.

most a very short distance, it seems to me that it must have turned its course into the sea. That is, of course, with the relative levels remaining as at present. That is what puzzles me. With Muir glacier retreating, and some distance away from this spot, how is a stream of water from the glacier going to be able to reach it? That Muir glacier did so retreat, and long enough to allow a forest growth on the mountains all around its basin to take place, is certain from the evidence there. (See my paper p. 223.) I thought it more probable that these gravels were deposited during a pause in the advance of the glacier which followed the recession, and when it was near this spot, simply because I was unable to conceive how otherwise streams could have reached this spot with their gravels. If this point is well taken the natural conclusion would be that the conditions were in some way different from the present, and there being no evidence as to what that difference was, so far as I found, nothing remained but speculation. Moreover the deposit reaches its greatest hight where it rests against the mountain slopes, in one place 600 feet above the water. Again, as you can see from the plate accompanying my paper, where the glacier rests upon these deposits they regularly decrease in hight as the ice increases in thickness, showing a diminution in hight toward the north. This may be due to the ice over it, but I doubt it.

This then is my main trouble about accepting your explanation. If Muir glacier should now retreat five miles, sea water, not forests, would occupy the large part of the territory deserted by the ice, and a long stream running along a narrow shore parallel to the coast line and building up a thick deposit thereon seems to me "agin Natur," as Josh Billings would say.

Munchen, Germany, Dec. 9, 1891.

The main objection which Mr. Cushing urges seems to be that the gravels are found on the borders of Muir inlet, but are absent from the central portion, where there is now deep water. If the explanation I have suggested is the correct one, we must suppose that the alluvial-fan spread out by the streams flowing from Muir glacier during its retreat, advanced southward and occupied the entire width of the valley, and formed a delta when the sea level was reached. Only the marginal portions of this deposit are now exposed; the central portion, and most of the surface, as suggested by Prof. Reid, having been eroded away. The greater erosion along the axis of the valley may have been due to the advance of the glacier which was capable of re-opening the central part of the channel where the ice current was deepest and most rapid, while remnants of the interglacial gravels were left at the sides.

Washington, D. C., Dec. 22, 1891.

EDITORIAL COMMENT.

THE SO-CALLED LAURENTIAN LIMESTONES AT ST. JOHN, NEW BRUNSWICK.

We are obliged to Prof. Matthew for stating concisely the evidence of the Archean age of the limestones which at St. John contain the newly discovered fossils mentioned in the GEOLOGIST for January, p. 55. We do not intend to take issue strongly with Prof. Matthew on a question pertaining to the geology of his own region. We only intended, in our note calling attention to the possible primordial age of the fossils he has described, to direct his attention to the lack of demonstration that they are of the age to which he has assigned them. Since he has taken the pains to question the validity of our doubt, we will state more fully the several facts which form its basis:

1. The base of the Taconic (which here we use as equivalent to primordial), is everywhere a quartzyte associated with a limestone. Usually the limestone overlies, but in some cases it is interbedded with or blended with the siliceous rock, constituting a fine-grained cherty limestone. It is not necessary to mention all the localities where this is known to be the succession. In Vermont it embraces the Granular Quartz and the Winooski marble, followed by a series of reddish, tufaceous, siliceous sandstones and shales which are probably the remote effects of oceanic volcanoes which broke out immediately after the deposition of the Winooski limestone. It is a desideratum to ascertain the stratigraphic succession from the limestone to the chronologically overlying strata in the Vermont district, but further south Prof. Dana has traced the limestone (under the name of Stockbridge limestone) through Massachusetts and Connecticut to Courtland, N. Y., where he found it upheaved and overwhelmed in the eruption of the Courtland gabbros. Intermediate points indicated that they took on the aspect of crystalline rocks, and indeed that much of the "Laurentian" of western Massachusetts and Connecticut (in which to this day no fossils have been found) is of the age, exactly or nearly, of these basal Taconic rocks. The mineral chondrodite was considered diagnostic of the Laurentian age of this limestone.

2. In Vermont characteristic Taconic fossils have been found

by Mr. Walcott in this quartzyte, and in northwestern New Jersey they have been found by Mr. Beecher in the same strata *associated with chondrodite.* These strata are unconformable below the later series at Rutland, Vt.

3. The Courtland (N. Y.), gabbros are repeated, and of the same age, in the Adirondacks. They here broke out at the same date and buried these strata under immense floods of eruptive rock. As in Vermont and in eastern New York this horizon is the great iron-bearing horizon of the region; but in northeastern New York an element is introduced into the iron which is not found when there was no actual outflow of basic rock, *viz.*, titanic ores abound, these being a characteristic native element of gabbro.

4. It is only recently that the effect of this early Taconic eruptive period has been located farther north, *viz.*, in the St. Lawrence valley. Mr. Ells has carefully described the so-called "Quebec Series" of the Canadian geologists. He has found the primordial portion of it to consist of two parts, *viz.*, a series of shales and sandstones, and a series of quartzytes and limestone, the latter series *being unconformable below the former.* This unconformity we take to mark the date of outbreak of the Adirondack and Courtland eruptives, and especially so as the rocks are said to contain large admixtures of volcanic materials, and as the lower strata are lithologically identical with those which antedated that outbreak in Vermont and New York. The red shales of the upper Sillery are the Georgia shales and sandstones of Vermont.

5. Without referring to intermediate localities, the stratigraphy of which might be considered, in this review, of questionable purport, we will mention only the succession in the Northwest. In northern Wisconsin, according to Prof. Van Hise, not only are the basal rocks of the upper iron-bearing series (the Taconic) a cherty limestone and a quartzyte, but *an erosion interval,* introducing a distinct non-chronologic succession and *an unconformity,* separates them from the later strata of what he has called Huronion but which we consider the later Taconic. Although there is a belt of gabbro rocks at other points in Wisconsin their relation to this erosion interval and to this non-conformity has not been pointed out by the Wisconsin geologists.

6. However, on the north side of lake Superior, where Prof. Matthew has described primordial fossils from the strata succeed-

ing this great break, this relationship has not only been inferred. but the actual date of the gabbro flood has been established by ample field evidence, and *there also* the quartzyte and the limestone (which latter however is almost wanting) are the only strata that are overwhelmed in the eruption. The Animikie black slates, which are abundantly interstratified with eruptive materials, mainly in the form of consolidated ash, making now various "greenstones," into which the slates graduate, followed the date of this eruption and fade off upward into the red shales and sand-stones that have long been known as characteristic of the Cupriferous series. These red shales we consider the chronologic analogue of the Georgia formation of Vermont, and the upper Sillery at Quebec.

7. The succession of geologic events and the order of stratification which have been worked out at St. John by Prof. Matthew., are, thanks to his statement of them, so nearly identical with what has been worked out in several places in the United States at the same geological horizon, that it seems the course of prudence to hesitate about continuing the old idea of the Laurentian age of those St. John limestones. The trend of evidence is toward placing them at the bottom of the Taconic. Whether they should be included in the Cambrian depends on the limits and definition which may be given to that term.

Below these so-called Laurentian limestones and quartzytes there is to be found, if the succession in New Brunswick is identical with that in the United States, a profound non-conformity. The older strata, the true Archean, are highly tilted, or vertical, and present their edges abruptly against the non-conformable overlying beds. This erosion interval has been pronounced by Dr. Lawson the greatest in geological history, and it is a datum of the first order for establishing, in North America, the base of the primordial series, for primordial fossils have been found in several localities, but little above this plane.

IN NEED OF AN EDITOR.

Far be it from the AMERICAN GEOLOGIST to disparage any effort, however humble, to spread the knowledge of any subject in the department in which it is itself engaged. With this feeling it welcomes to the field every new attempt to popularize the science of geology and its companion study, mineralogy. But all who seek to accomplish this end should themselves be at least ac-

quainted with the rudiments of the science. Otherwise they will be only blind leaders of the blind and will meet the traditional fate of such leaders and such led.

We take the following from the "Mineralogists' Monthly" for January, 1892. As this periodical has reached its seventh volume we think it should have outgrown its childhood and be incapable of perpetrating such enormities and of misleading those among its readers who know no better than its editor.

"Among other specimens we observed a six-sided prism of quartz which we were told by its owner was in a plastic state when taken out of the quarry. This gentleman showed us the portion of the prism he had cut off before the crystal hardened which it did very soon after being exposed to the air."

"We (the contributors of the note) are not sufficiently versed in the mysteries of mineralogy to be able to say positively whether a quartz crystal, however pure or impure, can be dissolved or made plastic by the action of strong acids except the powerful hydro-fluoric."

Again we read:

"A Passaic stone-cutter has a curiosity, a petrified rat, found in a block of brown stone. While preparing a six-foot block his chisel sank into a cavity The workmen thought it strange and laughingly advised him to examine it, suggesting that it might contain a diamond or a nugget of gold. He peered into the hole and was astonished on finding a petrified animal resembling a rat. Every part was well preserved. Experts are sure that it is a rat. The little creature's anatomy had remained perfect for all the period since the formation of the stone. Every claw, tooth and vertebra was present and well preserved. The skin had lost its hair and time had dried the form slightly but petrifaction had preserved it in its dark prison."

The stone-cutter's astonishment was justifiable, but there is cause for greater astonishment in the fact that at the present day an editor of a so-called scientific magazine can be found who is willing to publish such stuff. All editors get more or less of this sort of rubbish and while these stories may pay in a sensational newspaper they are utterly out of place, not to say disgraceful, in the columns of the cheapest scientific journal. Of what value is an editor if not to winnow out such chaff from the wheat? It is fair to presume that in this case the editor knows more than would be inferred from the extracts given above. Otherwise he would scarcely assume the position of conductor of the "Mineralogists' Monthly." But if he desires success in the field on which he has entered we counsel him to aim at a higher standard and to be more critical over the matter that he chooses for insertion. Otherwise even at fifty cents a year his periodical will "take in" rather than "be taken in."

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The three following papers are extracts from the Tenth Annual Report of the New York State Geologist, 1891.

1. *Notes on the genus Acidaspis*, 13 pp., 3 plates. By J. M. CLARKE. In his revision of *Acidaspis* and related genera the author adopts a relation towards the earlier work of paleontologists which it is to be hoped will be more generally followed. "To ascertain as far as possible from the descriptions by earlier writers, their intentions. The original diagnosis may have been brief, all too brief to satisfy the present requirements of our science, their illustrations insufficient or faulty, but it will not suffice to reject a name upon these grounds alone. 'Too imperfectly described to be identified,' is a decree which often veils an unbecoming aspiration after immortality unrelieved by an abiding conviction of the necessity and justice of making every effort to establish the results of another's investigations."

Ceratocephala, Warder, is retained and defined. Barrande objected to the use of this name on the ground that a very similar name had been proposed earlier by de Candolle, *Ceratocephalus*. "For us, however, the existence of de Candolle's term does not in the least affect the value of that of Warder, as the two words are different." In this connection we will restate a pertinent question recently raised in an editorial on "preoccupied names," in the *American Naturalist* for July, 1891: "If a difference of two letters is not enough to preserve two names, it becomes a question how many letters will constitute diversity, and so on. * * * The fact is the changing of a name which differs by a single letter from another name has no warrant in any rule or in common sense."

The author then gives the history of a number of related generic names which have more or less fallen into disrepute but are shown to have a sub-generic value. *Ceratocephala* is divisible into two sections; the first with (1) *Odontopleura*, Emmerich, (2) *Acidaspis*, Murchison (syn. *Acantholoma*, Corda), (3) *Ceratocephala*, Warder (syn. Trapelocera, Corda), and (4) *Dicranurus*, Conrad; the second section with *Selenopeltis*, Corda (syn. *Polycres*, Ronault). A new sub-genus, *Ancyropyge*, is established on *Acidaspis romingeri* Hall, with the generic relation nearest to *Ceratocephala*.

The North American species of which sufficient is known for sub-generic classification are arranged thus: *Ceratocephala*, Warder sensu stricto: C. goniata Warder (syn. *Acidaspis danai* Hall, *A. ida* Winchell and Marcy). *Acidaspis*, Murchison: *A. anchoralis* Miller=?? *A. cerulepta* Anthony, *A. Tuberculatus* Conrad. *Odontopleura*, Emmerich: *O. trentonensis* Hall, sp., *O. parvula* Walcott, sp., *O. halli* Shumard, sp., *O. crossota* (Locke?) Meek, sp., *O. o'nealli* Miller, sp., *O. ortoni* Foerste, sp., *O. callicera* Hall, sp., *Dicranurus* Conrad with *hamatus* Conrad. *Ancyropyge*, Clarke with *romingeri*.

2. *Observations on the Terataspis grandis Hall, the largest known trilobite*, pp. 6 and one folding plate. By J. M. CLARKE.

This valuable paper contains measurements of all of the larger trilobites known. We learn that with the middle primordial fauna some of the largest species of trilobites have their appearance; *Paradoxides* with a length of eighteen inches. The author mentions a number of very large Silurian and Devonian species of various genera. A large plate is devoted to a well-executed outline drawing of a restoration of *Terataspis grandis*, a species occurring in the Lower Devonian of New York and Canada. This restoration measures nearly twenty inches in length. If however, the largest cephalon yet discovered of this species were taken as the basis of a restoration the author says it "would represent an individual fully 24 inches in length, a size unsurpassed and unequaled by any other known trilobite."

"With this extravagant armor of defense and aggression, *Terataspis grandis* must have been easily lord of his invertebrate domain and no very palatable morsel for the heavily plated fishes of his day."

3. *Note on Coronura aspectans* Conrad (sp.), *the Asaphus diurus* Green. pp. 7, 1 plate. By J. M. CLARKE.

The New York State Museum of Natural History has recently obtained an entire individual of *Asaphus aspectans* Conrad, measuring 5⅞ inches in length. This specimen proves conclusively that *Dalmania helena* Hall, *Dalmania ohioensis* Meek and *Asaphus aspectans* Conrad, are one and the same species. The auther believes, however, that this species was described two years earlier than Conrad's by Dr. Green as *Asaphus diurus*. This species will therefore be known as *Coronura diura* Green, sp.

Correlation Papers, Cambrian. Bulletin No. 81, of the U. S. Geological Survey. C. D. WALCOTT. 8vo, 447 pp., Washington, 1891.

The second of the "Correlation Papers," is based upon an entirely different plan from its predecessor (No. 80, Devonion and Carboniferous). At the outset it is stated to be an "unfinished memoir." It is not a correlation essay in the strict sense of the term, but "an account of the present knowledge" of the Cambrian group. It is largely historical in its method, and the references to papers treating of the subject are very full and complete. This is shown by a list of 655 papers which are referred to in the course of the bulletin. The historical review of the literature occupies 187 pages. This is followed by a chapter on nomenclature, and this in turn by one giving a summary of the present knowledge of the formations. Problems for investigation, and the criteria and principles used by authors in the correlation of the parts of the group, close the volume. The Olenellus fauna is considered to mark the base of the group and the Dikelocephalus fauna the summit. This delimitation is based on the principles enunciated by Lapworth that a great geological group rests on the zoological features of its fauna and not on a local stratigraphical break; that the most reliable chronological scale in geology is that of zoological change; and that the duration and importance of any system in geology are in proportion to the magnitude and distinctness of its fauna.

temporary with, the greatest extension of the glaciers of the Glacial epoch. The author believes that the great weight of the accumulated ice caused a sinking of the earth's crust, and that such sinking had its complement in the contemporary rising of other areas nearly contiguous, or perhaps more remote, causing fractures, faults, volcanoes, laccolites and elevated domes.

Mr. Upham also traces a relation between the great ancient lakes (Bonneville and Lahontan) and the glacial period. The first flooded stage he considers was contemporary with the second glacial epoch, and the second high stage was due to a third epoch of glaciation in the northern part of the Cordilleran region.

These orogenic movements, so called by Gilbert and White, are to be distinguished from the epirogenic, which consist of slower and grander elevations of large continental areas. The unequal denudations of these larger areas result in the carving out of mountains which constitute Mr. Upham's sixth class—"eroded mountain ranges." Such are the Crazy mountains in Montana, and the Highwood mountains, twenty-five miles east of Great Falls. Turtle mountain, Pembina mountain, Riding, Duck and Porcupine hills in North Dakota, illustrate this structure. This epirogenic movement also took place at the close of the Cretaceous, or early in the Eocene. Indeed, the "Tertiary era seems to have been terminated, and the Quaternary ushered in, by a new epirogenic differential uplifting of this continent, causing the accumulation of the ice-sheet of the first Glacial epoch." * * * "There have been two epochs pre-eminently distinguished by extensive mountain plication, one occurring at the close of the Paleozoic era, and another progressing through the Tertiary and culminating at the beginning of the Quaternary era, introducing the ice age." * * * "With the culminations of both of these great epochs of mountain building, so widely separated by the Mesozoic and Tertiary eras, glaciation has been remarkably associated, and indeed the ice accumulation appears to have been caused by the epirogenic and orogenic uplifts of continental plateaus and mountain ranges."

Within the scope of the paper the author has gathered most of the collateral American data derived from a study of mountains, which go to illustrate, if not to demonstrate, his theory of the cause of the glacial epoch, viz., continental elevation.

General Account of the Fresh-water Morasses of the United States, with a description of the Dismal Swamp District of Virginia and North Carolina. By Nathaniel Southgate Shaler., pp. 255-339; with plates vi-xix, and 37 figures in the text. (Accompanying the Tenth Annual Report of the Director of the U. S. Geol. Survey.)

The swamp lands capable of drainage and use for agriculture in the United States, east of the Cordilleran mountain belt, are estimated to comprise somewhat more than 100,000 square miles. Professor Shaler states that fully one-fifth of the most fertile fields in Great Britain and Ireland, also large tracts in northern Germany and in the valley of the Po, have been won in such bog districts; and he believes that the aggre-

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Am. Nat.
pp 938-939
Am. Geol.
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The Penokee Iron bearing Series of Michigan and Wisconsin. By Roland Duer Irving and Charles Richard Van Hise, pp. 341-507; with plates xx-xlii, and five figures in the text. (Accompanying the Tenth Annual Report, U. S. Geol. Survey.)

This is an abstract of a monograph by these authors, which is now in press and will soon be published. A belt a few miles wide and about eighty miles long, extending from lake Gogebic, in the upper peninsula of Michigan, westward to lake Numakagon, in northern Wisconsin, is elaborately described; and the origin and relations of its rock formations and of its large deposits of hematite, recently opened by extensive mining operations, are discussed at length. Owing to the lamented death of the senior author after this work was far advanced, its preparation for publication has been chiefly done by his associate and successor in charge of the Lake Superior division of the survey.

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gate value of these now inundated areas in the eastern half of our country when drained and brought under cultivation, will be not less than that of all the present rich farming lands of Ohio, Indiana and Illinois together.

The processes of formation of the delta swamps of the Mississippi valley from the Ohio river to the gulf of Mexico are admirably described. This great river is remarkable in being the only one on our continent that has formed a delta filling the inlet of the sea at its mouth and projecting beyond the general coast line. From the indentations of the shore at the mouths of other rivers, the most notable being the Chesapeake and Delaware bays, into which the tributary streams have built no delta deposits above the sea level, it appears that the continent has lately been much elevated and more recently has undergone subsidence.

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The Penokee series, occupying a width that varies from a quarter of

a mile to about three miles, is underlain on the south by a complex group of granites, gneisses, and schists of Archæan age, and is overlain on the north by the interbedded eruptive and fragmental rocks of the Keweenawan series, the whole section having a steep northward dip. The Penokee and Keweenawan series are classed together as belonging to the recently named Algonkian period, between the Archæan or Laurentian and the Cambrian or Taconic, nearly equivalent to the Huronian period of the Canadian geologists.

A cherty limestone, attaining a maximum thickness of 300 feet, is the lowest member of the Iron-bearing series in the Penokee region. Whet er it was originally of chemical or organic origin is undetermined, but it gives no evidence of having been fragmental.

The next member, called quartz slate, is a detrital formation, averaging about 450 feet thick.

Upon this rests the iron-bearing member, in which all the known ore bodies occur. It is mainly about 850 feet thick, and consists of slaty and often cherty iron carbonate, ferruginous slates and cherts, and actinolitic and magnetitic slates. All these rocks are believed to have had a chemical or organic origin, none being accumulated as mechanical detritus. The ores are soft, red, somewhat hydrated hematite, derived by concentration from the lean carbonates of the formation through the action of infiltrating surface waters during or after the uplifting and partial erosion of the series.

Succeeding next above these strata is the upper slate member, the highest of the series, which in places is several times as thick as the three lower members combined. It is a slate or mica schist, chiefly composed of quartz and feldspar, and thin sections usually reveal its fragmental character.

The four divisions are conformable with each other through all their extent. Many dikes of diabase, varying from a few inches to ninety feet in width, intersect the series, which also in some portions contains interbedded sheets of diabase, apparently intrusions rather than overflows.

Elements of Crystallography, by GEO. H. WILLIAMS, PH. D. Second edition. New York. Henry Holt & Co. 1891.

The appearance of a second edition of the "Elements of Crystallography" so soon after the issue of the first, is the best proof of the need which has existed for such a book. Hitherto there has been no satisfactory exposition in the English language of elementary crystallography, if we except, perhaps, Bauerman's "*Systematic Mineralogy*," which has not met with favorable acceptance in this country, and which in some of its features is objectionable as a book for beginners. With the growth of the science of mineralogy, particularly on its physical side, with the increasing interest among chemists in the relations between chemical properties and crystallographic form and with the rapid modern development of petrography as one of the most important departments of geological science, there has sprung up in these various departments of

instruction a very urgent demand for an elementary text book of crystallography. That Prof. Williams' book meets this demand will be conceded by the great majority of teachers and students of the subject.

Apart from its practical aspects as an essential auxiliary to the study of mineralogy, petrography, chemistry and physics, crystallography has an important place in any thorough educational scheme as affording probably the best insight into the symmetry of natural forms; and in its philosophical suggestiveness as to the constitution of the universe, the study is entirely comparable to the study of elementary astronomy, the laws with which the student becomes familiar in both subjects being alike mathematically rigid and yet extremely simple.

For many reasons, therefore, it seems probable that the study of crystallography will in future play a more important role in American college and university curricula than has been its fate in the past, and we therefore welcome gladly this clear and concise treatment of the elementary principles of the subject as a vigorous step in that direction.

The book is not entirely above adverse criticism, but its shortcomings are few when compared with its many good qualities. The consideration of the theoretical possibilities as to the mode of molecular arrangement in crystals, which meets one in the opening chapter, might with advantage to the student if not to the book, have been postponed till the concrete actualities of the subject had been discussed. The numerous cuts throughout the book are well executed; and the two plates, one of limiting forms and the other of combinations in the isometric system, are all that could be desired. Prof. Williams is to be congratulated on the success of his book and of his efforts to present to American students in simple form a department of science whose proper treatment has up to the present been found only in the elaborate works of the German authors.

Systematic Mineralogy, based on a natural classification. THOMAS STERRY HUNT. 8vo, 391 pp. The Scientific Publishing Company, New York. 1891.

No student of mineralogy can pass beyond the stage of the novice without becoming painfully aware of the loose, if not chaotic, condition of its systematic nomenclature. The most trivial circumstance or quality has often been exalted above the fundamental principles of chemical composition in assigning a mineral species a name or a place in classification. In the infancy of the science it was necessary to apply such designations, but as these became often synonyms, or as they were multiplied through the labors of many investigators, it became apparent that some system of classification and elimination must be chosen. There sprung up two rival schemes, known as the "natural history" method and the "chemical" method. Werner, Mohs, Jameson, Breithaupt, Shepard, and, at first, Dana, employed the natural history method, and Berzelius, Clarke, Cleaveland, Phillips, Rammelsberg, and at last Dana, and nearly all later authorities, employed the chemical method. The former ignored chemistry, and the latter ignored the physical characters, speaking broadly,

and they were therefore at once, and continually, in antagonism. Meantime, as a common ground, on which they could compromise, the contestants, by the necessity of intelligent discussion, fell mutually into the practice of using "trivial" names for all mineral species, and as time elapsed these names have become, at this day, the only ones in use. The chemical classification, though not having any acceptable nomenclature based on it, has been strengthened by continual advance in the knowledge of the chemical composition of minerals, and in the philosophy of chemical combinations, until it is not too much to say that not any living author of systematic mineralogy, however strongly he may insist on physical characters, but discusses and depends largely on the composition of minerals for the ultimate determination of their places in his scheme. In nomenclature, however, there has been little or no change.

It is Dr. Hunt's task to show that physical characters are but the expression of chemical characters, and that they cannot be divorced, and that a "natural classification" must take cognizance of both. He has presented therefore a system which is both *natural* and *chemical*, and has covered it with a binomial Latin nomenclature which divides all the known minerals into classes, orders, genera and species. The classes and orders are determined essentially on chemical grounds. The genera are arranged from physical difference and resemblances, and the further definition of the species is the work of chemistry. All the mineral species are divided into four classes—Metallaceæ, Halidaceæ, Oxydaceæ and Pyrocaustaceæ. Order IV, in the class Metallaceæ, is thus composed:

Order IV. PYRITINEA.
Genus I. PYRITES.

Metallic sulphides $H > 5.\ c < 5$

1.	Pyrites	rutheneus	Laurite.
2.	"	vulgaris	Pyrite.
3.	"	secundus	Marcasite.
4.	"	cobalteus	Linnæite.
5.	"	niccoleus	Siegenite.
6.	"	cuprocobalteus	Carrollite.
7.	"	chromicus	Daubreelite.

The work, with its accompanying discussions of chemical philosophy and mineral physiology, is the culminating result of a life-long study. We consider it Dr. Hunt's *chef d' œuvre*, and the most important addition which American authors have made to the science of mineralogy. Dr. Dana's great volume, *System of Mineralogy*, is a vast compilation, arranged under a loose chemical classification, but makes no attempt to justify its philosophy—if it may be said to have any. On the contrary, Dr. Hunt's work marks an epoch in the science, as it discusses from new standpoints and readjusts, in accordance with the latest chemical philosophy, all the discordant material, and establishes a fundamental skeleton on which the future may build a symmetrical structure in mineralogy. It seems to answer to mineralogy as the classification of Linnæus does to botany.

Guide to Baltimore, with an Account of the Geology of its Environs. GEORGE H. WILLIAMS. Prepared for the American Institute of Mining

Engineers, Baltimore meeting, February, 1892, 12mo, cloth, pp. 139. Issued by the Local Committee.

Besides the usual announcements and descriptions of the institutions of the city this volume contains a concise account of the geology of Baltimore and its vicinity, with two geological maps, based on excellent contoured maps by the U. S. Geological survey ("Baltimore sheet"). The crystalline rocks are described by Dr. Williams, and the physiography of the origin and geology of the sedimentary rocks by N. H. Darton. It makes a very useful and valuable compend for the general student of the region.

Description of a new species of Panenka from the Corniferous Limestone of Ontario, by J. F. WHITEAVES.—(Can. Rec. Sci. Vol. IV, No. 8, Oct., 1891. pp. 401–404, with plate.)

Panenka grandis, the species described was collected at St. Mary's, Ontario. The specimen figured is six inches and four-tenths in length, and four inches and two-tenths in hight.

Note on the Occurrence of Paucispiral Opercula of Gasteropoda in the Guelph Formation of Ontario, by J. F. WHITEAVES. (Can. Rec. Sci. Vol. IV No. 8, Oct. 1891. pp. 404–407.)

A specimen figured has a length of 20 mm. and a breadth of 16 mm. They resemble the opercula of Litorina and Natica, and the conjecture is hazarded that they may belong to Holopea gracia or H. harmonia, of Billings.

Short Notes on some Canadian Minerals, by W. F. FERRIER. (Can. Rec. Sci. Vol. IV, No. 8, Oct., 1891. pp. 472–476, with plate.)

The minerals noted are *native arsenic* from near Thunder bay, lake Superior, *molybdenite* from Labador; *sphalerite* or *blende*, from Bauce Co., Quebec; particularly fine crystals of *pyrite*; *martite* from Lanark Co., Ontario; *kermesite* from Haut Co., Nova Scotia; *quartz* crystals with concave faces; black *spinel* from Ottawa Co., Quebec; *anhydrite* and *gypsum* from the Laurentian crystalline limestone of Lanark Co., Ontario.

RECENT PUBLICATIONS.

I. State and Government Reports.

The following bulletins of the United States Geological Survey have recently been issued: No. 62: The Greenstone-Schist Areas of the Menominee and Marquette Regions of Michigan, by G. H. Williams; No. 65: Stratigraphy of the Bituminous Coal Field in Pennsylvania, Ohio, and West Virginia, by I. C. White; No. 67: The Relations of the Traps of the Newark System in the New Jersey Region, by N. H. Darton; No. 68: Earthquakes in California in 1889, by J. E. Keeler: No. 69: A Classed and Annotated Bibliography of Fossil Insects, by S. H. Scudder; No. 70: Report on Astronomical Work of 1889 and 1890, by R. S. Woodward; No. 71: Index to the Known Fossil Insects of the World, including Myriapods and Arachnids, by S. H. Scudder; No. 72: Altitudes

between lake Superior and the Rocky mountains, by **Warren Upham**; No. 73: The Viscosity of Solids, by Carl Barus; No. 74: The **Minerals** of North Carolina, by F. A. Genth; No. 75: Record of North **American** Geology for 1887 to 1889, inclusive, by N. H. Darton; No. 76: A Dictionary of Altitudes in the United States, by Henry Gannett; No. 77: The Texan Permian and its Mesozoic Types of Fossils, by C. A. White; No. 78: Report of the Work done in the Division of Chemistry and Physics, mainly during the fiscal year 1889-'90, by F. W. Clarke; No. 79: A late Volcanic Eruption in Northern California and its peculiar Lava, by J. S. Diller; No. 80: Correlation papers—Devonian and Carboniferous, by H. S. Williams; No. 81: Correlation papers—Cambrian, by C. D. Walcott; No. 82: Correlation papers—Cretaceous, by C. A. White.

Explorations in Newfoundland and Labrador in 1887, made in connection with the cruise of the U. S. Fish Commission schooner Grampus, by F. A. Lucas. From Report of U. S. National Museum, 1888-89. Washington, 1891.

Preliminary Handbook of the Department of Geology of the U. S. National Museum, by G. P. Merrill. From Report of U. S. Nat. Mus., 1888-89. Washington, 1891.

Preliminary Report on the Coal Deposits of Missouri, by Arthur Winslow. Published by the Geological Survey of Missouri. Jefferson City, 1891.

Report on the Geology and Mineral Resources of the central mineral region of Texas, by Theo. B. Comstock. From Second Ann. Rep. of Geological Survey of Texas. Austin, 1891.

Annual Report of the Geological Survey of Arkansas for 1890, Vol. II, The Igneous Rocks of Arkansas, by J. Francis Williams.

Preliminary Report on the Utilization of Lignite, by E. T. Dumble, State Geologist of Texas

Geological Survey of Kentucky. Report on the Geology of parts of Jackson and Rockcastle counties, by Geo. M. Sullivan.

Geological Survey of Alabama. Report on the Coal Measures of the Plateau Region of Alabama, by Henry McCalley, including a Report on the Coal Measures of Blount county, by A. M Gibson.

Geological Survey of Canada. Contributions to Canadian Micro-Palæontology. Part III, by T. Rupert Jones.

United States Geological Survey. Tenth Annual Report. Part 1, Geology. Part 2, Irrigation.

Report on an Additional Water Supply for the city of Rockford, Ill., by J. T. Fanning, D. C. Dunlap and D. W. Mead.

CORRESPONDENCE.

Are the Eozoonal Limestones at St. John, New Brunswick, Pre-Cambrian?—In an editorial reference to Eozoon and the pre-Cambrian fossils of St. John, you appear to imply a doubt as to the pre Cambrian age of the latter; or at least that this may be an alternative with some who may admit the organic origin of the former; adding that other

limestones in the United States for which a Laurentian age had been claimed, had, on further examination, been found to be primordial [*i. e.*, Cambrian].

This, I think, can hardly be the case with the St. John limestones. The earthy (cryptocrystalline) condition of some of these limestones is apt to mislead those who expect to find Laurentian limestones (or perhaps I should say pre-Cambrian limestones) always coarsely crystalline. Hence Sir Wm. Logan, when he came here (about 1870) fresh from the survey of the limestones of the Ottawa valley, was surprised at the modern aspect of those near St. John. Dr. T. Sterry Hunt also, after his studies of the pre-Cambrian rocks of New England and the maritime provinces of Canada, classed these limestones in his Lower Taconic, below the Cambrian. Their comparatively unaltered condition is shown by the numerous carbonaceous bands, called, locally, "blue limestones," which are intercalated in certain parts of the terranes. In fact there are not only carbonaceous, but *bituminous* limestones present in this series, and this is shown by the fact that they give off a distinctly bituminous odor when struck with a hammer. This, however, is not an isolated fact, because a limestone in the Archæan tract of Scandinavia has been shown to contain bitumen, I think as high as 5 per cent. It is difficult to conceive of the introduction of this substance into a series of sediments except through the agency of organisms of some kind. Such we know to have been the source of bitumen in the rocks of later ages, and we naturally seek thus to account for its presence in these old limestones.

And yet, though in certain places these limestones show comparatively little alteration, they exhibit everywhere a secondary crystallization, often strongly pronounced, and not infrequently giving rise to highly crystalline, calcareous masses; the preservation of any organisms which may have been associated with the production of these limestones is therefore not only uncommon, but seemingly local.

Although comparatively modern in aspect, these limestones are no doubt pre-Cambrian, for the following reason: Subsequent to the production of the series of which they form a part, a great extrusion of igneous rocks (volcanic ash, scoria and mud) occurred in this district. These were piled up to a great thickness and spread over a wide tract of country; yet their thickness appears to have been very irregular, or denudation before Cambrian times swept away large masses of them, so that the underlying limestone series was brought near, or quite to the surface in some places.

The Cambrian rocks themselves have a clear foundation in certain conglomerates which overlie the volcanic series and show themselves along the borders of the Cambrian basins. These conglomerates are usually made up of fragments of the volcanic series, intermingled with quartz pebbles, but at one locality in the city of St. John, where the Cambrian rocks are in close proximity to limestone ridges, pebbles of the limestone are mingled in the conglomerate with those of the volcanic series, hence we cannot doubt that these limestones were hard rocks,

subjected to denuding agencies, at the time when the Cambrian sediments were being deposited in the submarine valleys near St. John.

Further—there is much negative evidence pointing to the same conclusion. If these limestones are post-Cambrian, to what age shall we assign them? The Cambrian terrane here includes the Lower Ordovician, and is an unbroken series of sediment. (See last volume this Journal, p. 289.) The Silurian (Upper) is present within twenty miles of St. John, and is a series of calcareous slates and earthy sandstones with characteristic fossils. The Devonian shales and sandstones, with plant remains, lie immediately south, separated from the limestones only by the basin of Cambrian rocks at St. John, about a mile wide; and the Lower Carboniferous conglomerates and shales actually overlie the limestones unconformably. There remains only the Upper Ordovician, which could possibly be represented in these limestones, and in limestones so little altered as some of these are, some trace of the abundant marine life of the Ordovician period should show itself; but none such has been found.

Altogether we see no reason to depart from the decision on the age of these limestones arrived at twenty years ago by the officers of the Dominion Geological Survey, that this calcareous series, isolated amid the Laurentian gneisses, mica schists and quartzites, is essentially of pre-Cambrian age.

Before closing I may say a word about the Cambrian rocks themselves. In my conspectus of the succession of faunas in the St. John group, given in a foot note on page 290 of the last volume of this journal, a section of "Upper Paradoxides beds, no fauna known," was introduced. By this it is not intended to be asserted that any of the later species of Paradoxides are known in the Cambrian rocks of the mainland of America; but only that the horizon indicated is the place where, if present, they should be found.

Another point of interest to students of the Cambrian is that *Hyolithes billingsi*, or a species very like it, has been found in the basal Cambrian rocks, near the middle of that series. This species was found by Dr. Charles Barrois and myself last summer, when examining the section in the eastern part of St. John county. The species is of interest as a common one of the Olenellus beds, being at the same time, according to Mr Walcott, a species of great vertical range in the Cambrian rocks of the Rocky mountains. G. F. MATTHEW.

St. John, N. B., Canada, January 13, 1891.

PERSONAL AND SCIENTIFIC NEWS.

THE WINTER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA was held at Columbus on Dec. 29, 30 and 31. The members were welcomed by the mayor of the city, Mr. G. T. Karb, whose address was replied to by the president.

The treasurer's report showed a balance of $280 unexpended, and that of the secretary, Prof. H. L. Fairchild, of Rochester, N. Y., showed the society to be in a prosperous condition.

At the first session the officers for 1892 were announced as follows:

President....................................Mr. G. K. Gilbert.
Vice-Presidents.......Sir J. W. Dawson, Prof. T. C. Chamberlin.
Secretary....................................Prof H. L. Fairchild.
Treasurer....................................Prof. I. C. White.

Two new fellows were declared elected. An excellent memorial of the late Prof. J. F. Williams, of Cornell University—a fellow of the society—prepared by Prof. J. F. Kemp, was read by the secretary and the reading of papers was begun. The first was by Prof. I. C. White, who gave a short account of the development of the Mannington oil fields in West Virginia, under his direction, and entirely on theoretical deductions from the geologic structure of the country. He showed the success that has attended these labors by the fact that only five per cent. of the wells drilled in these fields had proved dry holes. The attitude of the driller had, he said, changed from one of contemptuous neglect to one of studious attention. Some discussion and several questions followed Prof. White's paper.

Prof. White also made some remarks on a number of specimens of plants which had been sent to him by Mr. E. T. Dumble, state geologist of Texas, which clearly indicated a Permian horizon in the Wichita beds of that state. Among them, as identified by Prof. W. M. Fontaine, was a *Walchia*, the first reported from American strata.

Mr. J. S. Diller read a paper on the structure of the Taylorville region in California. There are, he said, 29 sedimentary and 17 eruptive masses. Several of the former are recognized by fossils. Eruptive rocks occur of an age from Silurian to Neocene. The Jurassic rests unconformably on the Trias. The Jurassic is completely overturned and sheared on a thrust-plane of low inclination. He instanced a fault which is believed to have a throw of four miles. The paper was full of facts and cannot well be condensed.

Prof. Hyatt exhibited a very large and interesting collection of Jurassic fossils in volcanic tuff, from California, and pointed out a number of important similarities and differences between them and their nearest European congeneric forms.

The Sierra Nevada of California was the subject of a paper read, in the absence of its author, Mr. J. E. Mills, by Mr. C. W. Hayes. This work has been in progress for several years at the trouble and expense solely of the author. The range is, he said, due chiefly to Tertiary movements, but recurring uplifts took place there in earlier times. The older rocks occur in the axes. The two crests of this double range lie on the eastern sides. The faults are normal. The Mesozoic rocks are folded and overturned but no arches occur, and apparently the thrust planes have been formed by pressure acting on blocks of strata lifted out of place by faults. There was apparently great difference of opinion between observers who had been at work on this field and the recorded observations in so difficult and contorted a region were not reconcilable.

A short note on secondary banding in the gneiss of Berkshire Co., Mass., was read by Dr. Diller, in the absence of the author, Mr. Wm. H. Hobbs.

Mr. C. W. Hall described the southeastern part of Minnesota. This region was first studied by D. D. Owen, 50 years ago, in his survey of the mineral lands of the Northwest. It contains rocks of Cambrian and Silurian date, with a small area of Devonian. The Cambrian contains the Keweenawan and the great red quartzite of the Northwest and the Potsdam sandstone, conglomeratic at base with pebbles of the same nature as the underlying rocks. After speaking at some length on the section as shown in Minnesota, the author mentioned the recent discovery of fossils in the St. Peter sandstone. Murchisonia, Endoceras, Helicotoma, etc., clearly indicate the Lower Silurian age of the sandstone. The beds below this are referred to the Cambrian, and include the two Magnesian groups of Owen.

An illustrated evening lecture was delivered on Tuesday evening by Mr. I. C. Russell on his recent attempt to reach the top of Mt. St. Elias. A large map of Enchantment bay enabled the speaker to explain the topography, both terrestrial and glacial, of the region. Many points, especially of the latter, were of very great interest to glacial geologists, in consequence of their bearing on the problems of the glacial era. Great changes in the level of the land were shown to have occurred in very recent times. Glacial beds were seen lifted far above their original level, and the retreat of the ice, which apparently is still in progress over the region, has exposed areas but lately buried deep under the glacier. Special views of the ice-fields were shown by excellent photographs on a screen. The deposits of morainic matter washed down from the glacier and deposited in the "glacial delta" showed large trees deeply buried, and, of course, dead. A very striking feature in the landscape is the great development of cryptogamic vegetation--mosses and ferns—forming a moist, soft cushion four or five feet deep, covering up fallen logs and unevenesses in the surface, and rendering progress slow, laborious and fatiguing. The glacial features of the mountain, its rivers, ice-falls, crags and peaks, were vividly shown in a realistic manner, so that this little known region was brought within almost familiar experience.

On Wednesday morning the business of the session was resumed by the reading of a paper on the Valley of the Rio Grande in Texas, by Mr. E. T. Dumble, the state geologist. It contained a detailed account of the Cretaceous strata of that region and some of their fossils.

Mr. W. H. Sherzer then read an elaborate revision of the rugose coral Chonophyllum, detailing its generic characters as regarded by himself, and maintaining that several species have hitherto been confounded under this name. He passed these in review, showing why they should be separated. Omphyma and Ptychophyllum were, he said, the forms with which it had been more frequently confused.

Mr. C. Willard Hayes gave an account of the geology of the Yukon valley in Alaska. He reported immense deposits of volcanic material, fine sand, dust, pumice, sometimes covering the ground as snow, and a distinct and diagrammatic display of an overthrust fault half a mile in extent. Along the seacoast, in the neighborhood of Mt. St. Elias, occur

large glaciers, one of which, extending across a valley, dams the stream and forms a lake of considerable extent. These glaciers lie almost entirely on the southern slopes, those flowing to the northward being inconsiderable in size. Indications of much greater extension of the ice in former times are abundant along this part of the basin, but farther to the north such signs are altogether wanting.

Mr. Stanley Brown read a paper on the Pribyloff islands of Alaska. Behring sea, from which these islands rise, is shallow, not exceeding 300 to 400 feet. Bogoslov, one of these islands, has been a central volcano from which have flowed the streams of basaltic lava of which it consists. These islands, especially St. Paul, are the home of the seals and sea lions, and the speaker mentioned the fact that numerous pebbles were found on these islands whose presence was very puzzling until it was explained that they were brought there in the stomachs of these animals.

Prof. W. J. McGee, in discussing the gulf of Mexico as a measure of isostacy alluded to the doctrine that areas of denudation are areas of elevation, while areas of subsidence are areas of deposition. Quoting examples from the geography of the area of the North sea, he explained the difficulty of estimating the area of encroachment in consequence of the building of artificial breakwaters and the construction of natural breakwaters by the sea itself. He next quoted the Soonderbands of India where immense subsidence has taken place and where the sediments of the Ganges and Sanpoo are now deposited, the great rivers of China, and, lastly, the gulf of Mexico, which receives on a small area the degradation products of the largest basin on the globe. In all these cases he argued that the two areas coincide and that the depression is roughly proportional to the deposition, but subject to so many sources of error as to render exactness at present unattainable.

Prof. G. F. Wright followed with a few remarks on the deduction which might be drawn from the presence of shells in a sandbed which he had discovered in Shropshire, England, during his recent visit to that country. His principal point was that the evidence tended to disprove the subsidence of that district in the glacial or inter-glacial era.

A short paper by Prof. J. C. Wolff described the structure of the Crazy mountains of Montana, which had been well illustrated by photographic views on the previous evening, and showed great alteration effects from the intrusion of masses of igneous rock.

Some new fishes from the Cleveland shale of northern Ohio, were briefly described by Prof. E. W. Claypole, and a few exhibited by their discoverer, Dr. W. Clark. The leading features of the now well-known *Dinichthys* and the more recent *Titanichthys*, whose structure has been so admirably elucidated by Dr. Newberry, were pointed out, and a new genus differing from both in the structure of its jaws and teeth was illustrated by drawings. For this we proposed the name *Gorgonichthys*. Allusion was also made to one or two at present somewhat obscure specimens.

Two papers by Mr. Warren Upham were read in his absence, the first

on the relationship of the glacial lakes following the ice age, and the second on the Champlain submergence.

A paper on the pre-glacial drainage of Summit county, Ohio, was read by Prof. E. W. Claypole, and illustrated by a map. He showed considerable difference between the courses of the present and the pre-glacial streams.

Other papers were read by titles in the absence of their authors, and the proceedings continued until late on Thursday afternoon in order to complete the programme.

Altogether the meeting was a pleasant and a profitable occasion for the members who were present. The society will meet next summer in accordance with its rule, at Rochester, N. Y., about the time of the meeting of the American Association.

MR. JOHN EYERMAN is in the south of France. All letters should be addressed to the care of Messrs. J. S. Morgan & Co., 22 Old Broad St., London, E. C., Eng.

PROF. F. W. CRAGIN HAS BEEN GRANTED LEAVE OF ABSENCE from Colorado College to enable him to do special work for the Geological Survey of Texas, on which he has been appointed assistant geologist. He has already entered upon his work in that promising field, and his address, till further notice, will be Austin, Texas.

DR. PERSIFOR FRAZER, of Philadelphia, sailed Feb. 27 for Genoa, and will be absent till May next.

MR. F. D. ADAMS, LECTURER IN GEOLOGY AND PETROGRAPHY in McGill University, and formerly of the Canadian Geological Survey, has assumed the duties of editor of the *Canadian Record of Science*, which is published quarterly in Montreal.

MR. RALPH S. TARR, of the New Jersey Geological Survey, has been appointed to the position at Cornell University left vacant by the death of Dr. J. Francis Williams.

DR. FERDINAND ROEMER, the distinguished German geologist, died at his home in Breslau, Dec. 14th, in his seventy-fourth year. He was not only one of the most eminent geologists of Europe, but his writings and investigations on this country, where he worked for many years, gave him a place among the most honored of our pioneer workers. It can be said truly that his works on the formations of Texas laid the foundation for the geological exploration of that state.

SIR ANDREW RAMSAY, late Director-General of the English Geological Survey, died at Baumaris, Anglesey, December 9, 1891, in his seventy-seventh year. He was at the head of the Geological Survey for nine years, retiring in 1881.

DR. T. STERRY HUNT, the most eminent chemical geologist of the United States, died in New York about the middle of February. His last work, which is reviewed in this number of the GEOLOGIST, occupied him in the last months of his long and diversified life, and served to round out with a satisfactory completion, the brilliant labors of a brilliant career.

A PECULIAR STRUCTURE IN HEMATITE.

THE

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A HITHERTO UNDESCRIBED PHENOMENON IN HÆMATITE.

By W. S. GRESLEY, F. G. S., Erie, Pa.

The specimen of which a portion is reproduced in photography (see plate V) is one of several hand samples kindly lent to the writer by a Miss Calver, of Erie, Pennsylvania, and it is to be regretted that all she can tell him about them is that a friend, who makes trips to the lake Superior iron region, occasionally carrying cargoes of ore to Erie, gave them to her about a year ago, so that the exact locality, the name of mine, nature of ordinary deposit in which they were found, depth, and so forth, cannot (at present, at all events) be ascertained.

The ore is a fibrous red hæmatite, evidently of great purity (possibly 70 per cent. metallic iron), reddish-blue in color, of smooth and somewhat unctuous feel, and very compact and tough looking: small groups or bundles of the fibres chink like iron nails when shaken up together in the hand. The fibres run in a curved form, thus giving the hand-specimens a more or less curved or horny shape. The samples examined vary in length between two and nine inches, but as the longest of them has lost its inner extremity, its *root* or commencement of growth, so to speak, it may have been an inch or two longer when whole. The specimens do not fit or exactly belong to one another, but from their peculiar likeness have evidently all come from the same deposit or mass in the mine, wherever that may have been. The center or centers of formation appear as small flat cavities. (*i. e.*, supposing the thin ends of the fragments examined represent the commencement of their formation outwards around these nuclei.)

They are fragments of botryoidal or reniform masses of ore, and thus are of *secondary* origin. Starting away from the nuclei the ore has very much the form of fangs of double teeth—blunt, irregular, conical aggregations of fibres, now without any filling of any material between them, though when *in situ* may have had red powdery ore or clay among them. Concentric structure is exhibited in one of the fragments.

Now what is most peculiar in these samples is that they have holes through or running in them at different distances from the nuclei and from one another. Three inches is about the distance of the nearest hole seen from a center of growth, and those best preserved are clearly shown in the plate.

The points or chief characteristics to be noted appear to the writer to be:

a. The shape or form of these holes or little tunnels.

b. The fact that they run roughly parallel to one another or at right angles to the fibres of ore, namely: nearly square across or through the specimens.

c. The peculiar curvature of the grain of the ore surrounding these apertures, particularly clearly brought out in the case of the left hand or perfect hole seen in plate.

d. That, beyond or to the right hand side (as viewed in photo) of these pear-shaped tunnels there exists a straight, smooth kind of "bedding plane" running forward to the next hole (where the fibre is bent round), or right to surface or exterior of specimen, as shown between A and B (lower side of view).

e. The apparent fact that had the formation of the ore continued beyond B C, the outermost hole—really a groove or channel now, because open on one side—would have been closed over in like manner to that seen about three inches to rear of it. [Of course it will be seen that the lower of the three "holes" is only half there, the corresponding half being broken away with the rest of the mass.]

f. All the holes have the same cross section in form and measure, just about the same diameter—a little over ¼ inch the shortest way. Under a pocket lens the surface of parts of these holes (their walls) is seen to be mammillated, and throughout they are coated with a soft skin or film of red iron oxide.

The outside surface of the specimen, *i. e.* between B and C, the edge of which is here shown, is oddly polished, though not artificially, I think. This edge or surface represents the limit of growth of

the mass in that direction. Of course, one is at once inclined to ask: What do these holes represent, and whence came they? Were they once filled with ore or with any other mineral matter? etc. While the writer does not pretend to give any satisfactory explanation of this curiosity, he would like to remark one or two things.

These cannot be holes drilled or eaten out, or burrows made by worms or animals of any kind; nor have they been made by the hand of man. The form or arrangement of the structural fibre of the ore in vicinity of the apertures is altogether against such theories. The writer possesses various English specimens of clay ironstone. one of which is now hæmatite (having been altered by peroxidation of iron and water in contact with red strata of Permian age), perforated by worm burrows, which are now either filled with pink calcite, with fossil slime secreted by the worms, or are empty.

We are unfortunately in the dark as to which way this illustrated sample lay or was formed *in situ*, but the writer conjectures that in whichever direction it was accumulated or grew, the mass in forming met with some obstructions, around which it continued to grow and even to entirely envelope in most cases. What such supposed obstructions or projections were, seems to be the point from which to arrive at a satisfactory conclusion of the growth of the ore. It has occurred to the author that possibly stalactitic ore was there first and that this fibrous variety formed around and amongst the stalactites. But stalactites do not take the form which these holes show. Usually they are rudely cylindrical or long, tapering cones; and, if once present why are no remnants left now? Twigs, wires or narrow pods would seem to suit better. Whatever may have been there is now gone from the samples examined, for all the holes are empty.

It seems impossible to regard them as elongated air holes, or bubbles, for the texture and form of the ore has not been altered from what it was when first formed into this condition; there has evidently been no squeezing, no metamorphism, no fusion, vitrification, elongation or shortening of the mass; it shows to-day just as it was after or even during process of formation, or *growth*, as we may fairly term it. Can it be possible that the mass has formed *in situ* around or in contact with a number of lengths or coils of wire, in some place in a mine, where the conditions have been very favorable for a very rapid growth? We know that agates are produced in a very short space of time under favorable circumstances: I refer to the German samples artificially made

out of natural mineralized water in some of the mines or caverns there. Certain forms of gypsum too, have been known to form within a few years; and I am here reminded of the fact of a man being lost in the great Dalecarlian copper mines, at Falun in Sweden, in the last century, whose body when discovered, was partially converted into a yellowish gypseous mineral, it having, as is supposed, fallen into or become covered with mine-water. Stalagmite, sinter, tufa, etc., do form quickly, as in the vicinity of hot springs, "petrifying wells," in caves, in old mines, etc. Quite hard and thick deposits of lime, iron, etc., are frequently found in mine water-pipes, cisterns, in old "atmospheric engines," and other places where conditions favor their deposition; however the writer cannot call to mind an actual case of hard pure iron ore proved to have formed within ancient or modern history, unless certain curiosities taken occasionally from blast furnaces (results of peculiar melting and deposition in connection with other mineral substances) may be regarded as such, or the instance quoted by Bischof in his "Chemical and Physical Geology" of three feet thick of limonite occurring over a substance containing Roman coins, in central Europe. Swedish "bog iron-ore" is stated to form at the rate of several inches in a few years. The writer remembers a very singular case of rapid growth of a specimen from a coal mine in Staffordshire, England. It was placed in a cabinet and being left to itself for twenty-five years, was at the end of that time found to have eaten its way upwards through one inch of wood (the top of the cabinet,) and downwards through three earthenware plates on which it was placed. Its owner stated that its growth in bulk had since been so extensive he had broken off fragments, to keep it within bounds, to the extent of five or six times its original bulk. Scientists who had examined this specimen consider it to be a variety of *copiapite*, or ? *coquimbite*. *Alunogen* or "*hair-salt*," or ? *ferrous sulphate* is another mineral of rapid growth in favorable situations; the writer measured some fibres in an entry in an English coal mine, in May, 1880, which entry had to his own knowledge been driven about eight years. The longest fibres were 11½ inches, thus giving an average annual growth of nearly 1½ inches. Other facts might be cited, but enough has been said here to show that whether fibrous hæmatite can or cannot form rapidly under favorable conditions, many minerals or combination of minerals can and do *grow* amazingly fast.

Additional specimens of this lake Superior ore, could they be

procured, might throw light on the subject. The general aspect of this singular variety of ore of iron, so strangely resembling split wood, suggests the name of "*Wood iron-ore*" for it, but the grain in wood passes around knots, or holes once occupied by knots, in a different way from the grain in this iron-ore.

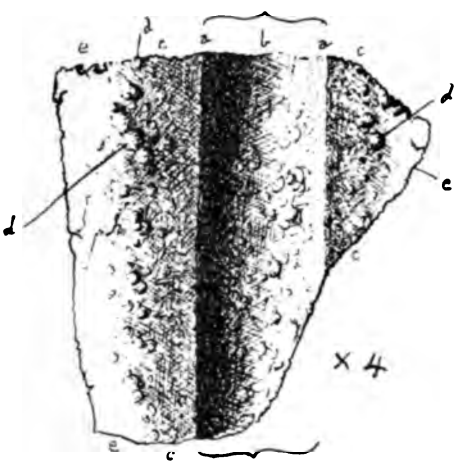
The specimen in question can in no way be regarded as *pseudomorphous*, or be a *replacement* formation after *limestone*, *dolomite*, *pyrite*, *chalcedony*, etc., nor is it a *fossil* (mineralized wood) or anything of that description.

Erie, Penn., U. S. A., Nov., 1891.

ERIE, Pa., Dec. 15, 1891.

PROF. N. H. WINCHELL.

DEAR SIR: Acting on your suggestion, I have polished one end of the sample through one of the holes, and beg to inclose drawing and description. I cannot see anything here attributable to *wood-tissue.* The dull polishing portions, *c c*, are the sides or walls of the hollow *a b a*, and may be insusceptible of taking a higher polish because the fibres of the ore here are bent in the direction of the hole, as you will notice in the photo (plate V).



Enlarged view of polished transverse section taken through, or on the plane of one of the tunnels or empty holes of this ore.

The hole lies between *a a*, the portion left on the specimen being about $\frac{1}{20}$ inch deep in the center, as at *b*. This portion (*a* to *a*) is, therefore, not polished; *c c* are the two walls of the hole, the ore of which does not take a good polish. This part of the ore exhibits harder and brighter spots, *d d*, which gradually merge into the compact, hard ore, *e e*, (the unshaded portion of the surface treated), which takes a high polish. The surface of the hole (*a* to *a*) is, as shown, slightly mammillated and coated with red, powdery ore. W. S. GRESLEY.

THE LOWER COAL MEASURES OF MONONGALIA AND PRESTON COUNTIES, W. VA.

By S. B. Brown, Ass't Professor of Geology, W. Va. University, Morgantown.

For ten or twelve miles south of Morgantown, W. Va., the Monongahela river flows north along the strike of the Barrens with the Lower Coal Measures just rising above water level. The Mahoning sandstone at the base of the Barrens in this region is 100 to 150 feet in thickness, and the banks of the river are for long distances crowned with its high cliffs which, in many places, have weathered into fantastic forms. The streams that flow into the Monongahela from the east have worn deep and narrow gorges, whose steep sides are held up by the massive masonry of this Mahoning sandstone.

But it may be seen in ascending these streams that the strata bounding their sides are rising faster than the stream beds; hence lower and lower strata emerge from the water level, until at six or seven miles east of the river, the whole of the Lower Coal Measures outcrop along the hillsides, and the Pottsville conglomerate begins to show its pebbly surface along their banks.

Starting three miles above Morgantown, at the mouth of Booth's creek, with the Upper Freeport coal at the river level, 800 feet above tide, and following up this stream to the southeast, we find the coal constantly rises higher above the water, until at Old Clinton furnace, six miles distant, it is 165 ft. above the same, while at Halleck, on the Chestnut ridge anticlinal, it is in the tops of the hills, and 1,900 ft. above tide.

This Chestnut ridge anticlinal forms a true watershed, and divides the streams flowing into the Monongahela from those flowing into the Tygart's valley, at Grafton.

From Halleck, continuing southeast, we follow down Laurel run to Irondale furnace, and observe that the strata have dipped in the direction of our course almost as fast as the descent of the stream, until at Irondale the Upper Freeport coal is but 1,000 ft. above tide.

On reaching Newburg, the strata are again rising east, so that we have crossed the trough of the Ligonier syncline and find the Upper Freeport coal at 1,050 ft. above tide. At Austen, three miles further east, it is at the level of the B. & O. Railroad track, and 1,560 ft. above tide; at the Kingwood tunnel it is 1,800 ft. above the sea, and after a small dip to the east it again rises, and

near Eighty Cut, at 1860 ft, A. T., it passes into the air and is seen no more on the western side of the Allegheny mountains.

The whole length of this section, embracing one great anticline, one syncline, and reaching to the crest of another anticline, is about 30 miles, and along it in several places complete sections of the Lower Coal Measures are exposed.

Between the Mahoning sandstone and the Upper Freeport coal, near the river, there are usually about 40 ft. of dark colored shales, that in places yield numerous fossils, but on going east these shales rapidly thin out, and the sandstone then lies immediately upon the coal, forming an excellent roof.

On ascending White Day creek to Garlow's mill we find the Lower Coal Measures fully exposed and the section shown in cut No. 2 was obtained there. The Mahoning sandstone here lies immediately upon the Upper Freeport coal. The section reads as follows:

1.	Upper Freeport coal	4′	
2.	Shales	25′	
3.	Limestone	4′	
4.	Shales	6′	
5.	Fire clay and iron ore	3′	
6.	Shales and sandstone	75′	
7.	Upper or Middle Kittanning coal	5′	3″
8.	Limestone	2′	
9.	Sandstone and shales	40′	
10.	Lower Kittanning coal	4′	
11.	Shales	35′	
12.	Sandstone, massive, perhaps Homewood S. S.	15′	
13.	Shales	30′	
14.	Coal	1′	
15.	Shales	10′	
16.	Main Pottsville conglomerate	...	
	Total	259′	3″

About six miles up Booth's creek, at Haigh's bank, the Upper Freeport coal shows the following section, descending:

Coal	0′	3″	4′ 6″
Shale	0′	6″	
Coal	2′	6″	
Shale	0′	2″ to 3″	
Coal	1′	0″	

At Stevens' bank, in Winfield District, Marion county, it shows:

Coal	2′	6″	3′ 10″
Shale	0	2″	
Coal	1′	2″	

At Isaiah Robes, on Whiteday creek, it is very excellent, 4½ ft. thick, with 2″ to 3″ of shale, 1 ft. from the bottom. All of these openings are on the western slope of the Chestnut ridge an-

ticline. Further eastward, in the Preston county basin, the coal shows about the same structure, but is twice as thick, being 7 to 9 ft. at numerous openings. It is valuable as a coking coal, and is used for this purpose at Irondale, Newburg and Austen. Its roof shales show fossil plants, Calamites, Sigillaria, Neuropteris flexuosa and N. hirsuta.

Along the river near Little Falls and also in the Preston county basin, the Upper Freeport limestone occurs at from 20 to 25 ft. below the Upper Freeport coal, but along the Chestnut ridge anticlinal it seems to be absent, or but poorly developed. It varies from 2 ft. to 8 ft. in thickness, and on weathering shows a minute univalve fossil.

About 35 ft. below the Upper Freeport coal is an horizon at which fire clay and iron ore are often found. The iron ore is a siliceous shell ore, and was formerly manufactured into iron at Clinton furnace. At one place a seam of coal is reported underlying the ore. This seam may be the Lower Freeport coal.

The next 75 ft. consists of shales and sandstones, the interval consisting mostly of shales in the western part of this district, but toward the mountains, these are replaced by a massive sandstone that is quite coarse and pebbly and has about the same thickness.

The next stratum is known over a large district as the "three ft. vein of coal," although its thickness is quite variable. On White Day creek, this bed shows the following structure:

Coal	2'	0"	
Shale	0'	1"	
Coal	0'	10"	5' 2"
Shale	1'	3"	
Coal	1'	0"	

Only the two upper benches of coal are mined; the 15 inches of shale in the bottom being too much to remove for the 12 inches of coal beneath. The roof here is of thin bedded sandstone and is excellent. Elsewhere along the Chestnut ridge anticlinal, this coal is seldom over 2 feet in thickness, and usually has porous, sandy beds for a roof that are incapable of sustaining great pressure.

Prof. White shows this coal to have the following structure in the Newburg shaft:

Coal	1	0"	
Slate	0	3"	
Coal, slaty	2	0"	7' 3"
Fireclay	2	0"	
Coal, good	2	0"	

Immediately under this coal is a limestone about 2 ft. thick.

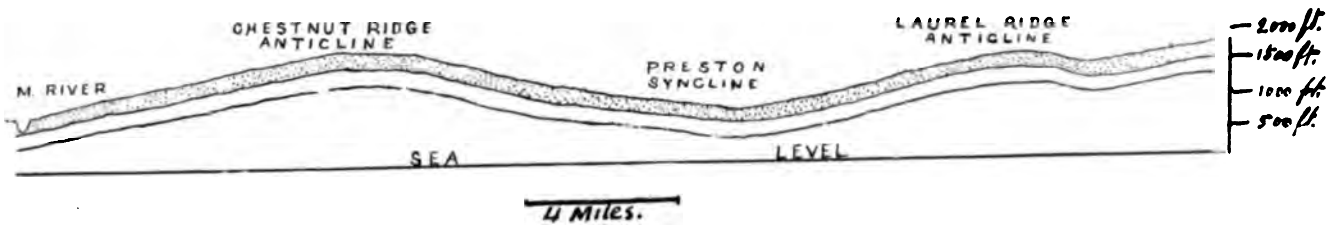


FIG. 1. PROFILE SECTION FROM NEAR MORGANTOWN, W. VA., THIRTY MILES SOUTHEASTWARD TO EIGHTY CUT.

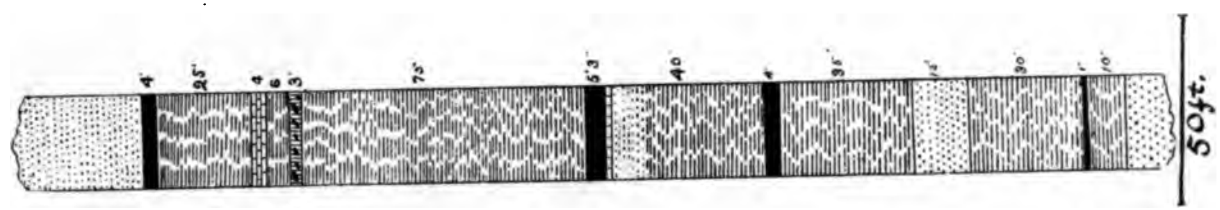


FIG. 2. PERPENDICULAR SECTION IN THE LOWER COAL MEASURES, WHITE DAY CREEK, W. VA.

At other places in the same neighborhood there is one foot of shale between the coal and limestone, while in the vicinity of Clinton furnace, the limestone is more siliceous, highly ferriferous and 10 ft. to 12 ft. of sandstone divides it from the overlying coal. This limestone is the Johnstown cement bed of Pennsylvania.

Descending, we next pass through 40 ft. of flaggy sandstones and shales and reach a stratum of black shale, usually about 1 ft. thick, filled with fossil plants, calamites, Lepidodendra, Neuropteris hirsuta and Pecopteris of various species. The black shale is the roof of a very important seam of coal, the Lower Kittanning, the most extensive coal seam of the Appalachian field. It varies greatly in thickness, but is nearly always workable. In the western part of our section it is four feet thick: in the Newburg basin it is over seven feet in thickness. In the vicinity of Halleck, this coal shows the following structure:

Coal	0′	2″	5′ 8″
Shales	2′	6″	
Coal	2′	0″	
Shales	0′	2″	
Coal	0′	10″	

Although it is all good coal the lower stratum of ten inches is of very superior quality and is much used by blacksmiths. Indeed, it is to its value for this purpose that the whole seam owes its high reputation.

In the bottom of the shaft at Newburg, it shows the following complex structure:

Coal	0′	10″	9′ 5″
Shale, gray	0′	10″	
Coal	0′	6″	
Coal, bony	0′	3″	
Coal, main bench	4′	6″	
Black slate	0′	6″	
Coal	2′	0″	

Under the Lower Kittanning coal, we have 35 ft. of shales and clays bearing iron ore nodules near the bottom. It is this iron ore that furnishes a cause for the number of chalybeate springs that occur at this horizon along Chestnut ridge.

Next comes a hard-pebbly sandstone that is usually about 15 ft. in thickness, filled with impressions of large plants, Sigillarids and Lepidodendra, and which resembles the "Great Conglomerate." This is perhaps the Homewood sandstone, of Pennsylvania, the uppermost member of the Pottsville conglomerate series.

This rock makes a sharp change in the topography wherever it appears above the surface. It does not disintegrate easily, and hence usually makes an abrupt cliff, while its great boulders are scattered far down below its present outcrop.

Under this hard sandstone, we find about 30 ft. of sandy shales filled with plant fossils. Then one foot of hard, black slate caps one foot to one and a half feet of coal. This coal is often worked and is of good quality.

About 10 feet of shales underlie this coal, which brings us down to the main mass of the Great Conglomerate.

W. Va. University, Dec. 12th, 1891.

THE TIN ISLANDS OF THE NORTHWEST.

E. W. Claypole, Akron, O.

I.

The Cassiterides or Tin islands of the ancients were the granitic masses of Cornwall and the Scilly islands. Hither came in days before the dawn of written history (except perhaps Egyptian) the enterprising mariners of Tyre, to buy from the Britons their much prized and very scarce metal. By craft and daring in navigation, they for many years kept the destination of their tin-ships a profound trade secret. Few dared follow them out between the pillars of Hercules into the foggy and stormy Atlantic, and Phœnicia was consequently for ages the central mart for the sale of this metal—the stannary of the world.

Not, however, for the sake of tin pure and simple, did these old Phœnician mariners undertake the voyage from the Levant to St. Michael's Mount and back—6,000 miles of sea, and often out of sight of land. Tin alone (the *plumbum album* or white lead of the Romans) was of little use. Pliny,* it is true, speaks of tinning copper vessels, but Pliny lived at a comparatively late date. It was the peculiar and intense hardness that characterizes its alloy with copper that gave this metal its value among the ancients. Bronze was the material of which all metallic cutting tools were made before the discovery of steel, and for many years afterwards until this latter became cheap and easily wrought. It is therefore needless to point out the great advantage possessed by the nation that held the secret of the Cornish tin. Others

*"Stannum illitum aeneis vasis compescit aeruginis virus." Plin. 34, 48.

could buy the bronze after it had been made, but could not make it, and this, there is abundant reason to believe, was done.

Even after the introduction of steel had destroyed the value of bronze weapons, so many uses for tin remained that the old Cornish mines were never entirely closed, though in the time of the English Plantagenet kings the royalty had dwindled down almost to nothing.

II.

Rising like islands from the vast prairies of the Northwest are the Black Hills of Dakota. They break through the monotonous plain that extends from Chicago to the foot of the Rocky mountains. Their steeply inclined axial strata are in strong contrast with the flat beds of the Cretaceous and Tertiary eras around them. To these, as to the new Cassiterides, much attention has been directed for some years past, in the hope that the future tin supply for the markets of North America will be drawn herefrom.

To the geologist these hills are equally interesting on account of the problems which they suggest, and the facts which they reveal concerning the evolution of the Northwest.

Prof. N. H. Winchell and Mr. Henry Newton were the earliest explorers in this field, and entered on its investigation while it was still in a wild state, and occupied by hostile tribes of Indians. To their work the present writer, and all who have followed them, are deeply indebted for facts and data. The writer's own observations have been made mostly in the southern tin-district, and in some parts of the east and north of the Black Hills.

III.

The core or medial axis of the Hills consists of a ridge of schists and slates dipping at a high angle to the east, and often nearly vertical. Of these the schists are the older and underlie the slates. They are very micaceous, and often so full of garnets as to appear red, and have been likened by Profs. Blake and Crosby to the "Montalban" series of New England. These schists are heavily charged with lenticular sheets of a very coarse granite composed of quartz, albite and mica, which have been described by some as intrusive. But the evidence rather justifies the belief that they are really veins of segregation, as they uniformly agree with the schists in strike and dip. These veins are

very striking to one only acquainted with granite in its usual form—a finely granular mass. The quartz is as usual, disseminated, but the albite, the chief ingredient, is found in very large crystals, and the mica in sheets sometimes a foot or more in diameter. With these occur crystals of black tourmaline occasionally weighing several pounds, and magnificent spodumenes, ten, twenty and thirty feet long in the rock. Here too, are found beryl, cassiterite (tin-ore), columbite, and other minerals often associated with these.

These intercalated veins of coarse granite weather less rapidly than the schists and consequently stand out in bold relief on the hillsides, their wreckage strewing the ground so as to convey the impression that the granite area is much larger than is really the case. No massive granite exists in the Hills, even the central Harney peak being composed chiefly of schists. The veins run in some instances for long distances—many hundred feet or yards—but eventually disappear to be succeeded by others in parallel lines.

The presence of the cassiterite in them has drawn attention to these schists almost to the exclusion of the other strata of the Hills. We will return later to this topic when treating of the tin.*

IV.

The eastern slates overlying and conformable with the schists compose the younger part of the axis already alluded to. They occupy the whole eastern side of the mass of the Hills, and like the older schists dip steeply to the east. They are hard and blue or dark grey, have no true cleavage, and weather into ragged peaks or edges. So far as it is known they contain no useful minerals. Vast beds of quartzite are found in them so massive as to justify calling them at times sandstone deposits.

V.

Both the formations above mentioned belong to those early ages of geologic history or rather legend, which are at present comprehended in the term "Pre-Cambrian." It would be more

*It is worthy of remark in this connection that the stanniferous veins of Dakota are immensely older than those of Cornwall. The latter are all of post-Devonian age, and probably in some cases very much later than the Carboniferous. Indeed it would seem as if the process of the deposition of cassiterite were continuous, as it is not uncommon to find in Cornwall recent deer-horns so impregnated with the mineral, that they are as rich as the average ore of the county.

strictly logical to write "Pre-Potsdam" because we can only prove that they antedate that era. But the total absence of fossils and their structure and immense thickness point strongly to a Pre-Cambrian date. Regarding the last character Prof. Newton writes:

"The whole thickness of vertical rock with a width of about twenty-five miles, is believed to retain its original relation of parts." So great a thickness of even Pre-Cambrian strata is scarcely credible.

Immense beds of conglomerates are a feature of the slates, and are well displayed in many places, as for example, near Lead City on the railway. The pebbles consist chiefly of glassy quartz and quartzite, both of which are found in the older schists, but the conformability of the two series forbids our ascribing them to that source, and compels us to seek some other and more distant origin. The pebbles of quartzite are elongated, says Prof. Crosby, but those of quartz are not.

Prof. Crosby has also called attention to a vast sheet of diorite (plagioclase felspar and hornblende), sometimes auriferous, which passes through the entire length of the eastern or slaty series, and of which abundant fragments may be seen on the eastern slopes, and also to massive but very siliceous beds of hæmatite like those of the lake Superior region. He has further demonstrated from the presence of limestone pebbles in the Potsdam, that a bed of this material must be covered up somewhere in the Hills. This discovery may some day throw light on the age of the slates, some of which may, though such a supposition is scarcely possible, be of lower Cambrian date.

VI.

After the deposition of the series above described in the sea of Pre-Cambrian age, an elevation of the region took place whereby the schists and slates were bent and folded at a very high angle and the Black Hills of Dakota were born. If we must regard the whole series as one unduplicated mass, they form a monoclinal ridge with strong easterly dip. This movement alone indicates a long time, but the enormous erosion which the strata suffered before the Potsdam sandstone was laid down upon their basset edges forbids any doubt on this point. The interval represented by this gap extends from the date of the latest slate to that of the Upper Cambrian, and may include the whole of Lower

and Middle Cambrian time, with possibly some earlier eras. During all these aeons the Black Hills stood as an island or as islands in the Cambrian sea, supplying by their wear and tear under the action of the weather and the waves the sand required for the building of the Potsdam sandstone.

The elevation which had set in after the deposition of the schists and slates, at length ceased and subsidence ensued. The sea began once more to submerge the sinking land, and the Potsdam sandstone already forming in the surrounding sea encroached on the island. As the water advanced it destroyed the superficial parts of the old land, and deposited the material as the Potsdam sandstone. This is seldom more than 250 feet thick, and is conglomeratic at base containing pebbles of all the harder rocks found in the hills, as well as of the limestone above mentioned. These last occur all round the Hills, and in some places compose almost the whole of the basal conglomerate.

There can be no reasonable doubt of the identification of the Potsdam, though no fossils have yet been found. It is probably continuous from its eastern outcrops beneath all the other palæozoic strata. But the slightly calcareous nature of its upper layers and the few fossils which they have thus far yielded, indicate that these may represent strata much higher in the scale. This will be more evident after consideration of the next topic.

VII.

If the sandstone be referred entirely to the era of the Potsdam, then there is a second long gap in the strata of the Hills, including all the Ordovician, Silurian and Devonian eras. But if the qualification just stated be allowed then the gap only includes the Ordovician and Silurian eras—a time sufficiently long. Prof. Carpenter has discussed this question, and has adopted a suggestion first put forth, I believe, by Prof. Crosby. The former says:

"It was shown by the Challenger Expedition that in the truly abysmal depths of the sea, there is, properly speaking, no sedimentation These are the red clay areas which form a characteristic feature of the deeper portions of the sea, and are found at all depths from 2,000 fathoms down to the deepest abysses. They consist of exceedingly fine clay colored red with oxide of iron. This clay is not a sediment, having its origin in the erosion of the land, but is derived from the aluminous portion of shells, decomposed pumice and fine volcanic ash." "So slowly is this accumulation taking place that the ear-bones of whales and the teeth of

sharks believed to have been extinct from early Tertiary times, have not yet been covered with it."

"The point that I wish to make is that if this section sank to these abysmal depths during Silurian and Devonian times, it reached a depth in which there was no sedimentation, and hence rocks of these ages are absent. A slope of only one degree would in two hundred miles from the shore have carried it to the depth of 3,000 fathoms, or far into the red clay area."

Though the acute hypothesis above stated can scarcely be assumed at present, yet one fact strongly confirmatory must not be forgotten. When sedimentation again set in limestone and not sand was deposited, indicating distance from shore.

Though apparently unique thus far in geology as an explanation of the absence of strata, it is certainly at least plausible, and none of the objections urged against it have sufficient weight to form an insuperable obstacle in the way of its acceptance. On this view the Potsdam subsidence continued until the area of the Black Hills had sunk below the 3,000 fathoms level, and of course the tops of the highest peaks were covered with water.

On the cessation and reversal of this movement, the first sediment that covered the bottom of the rising area was that of the Carboniferous limestone. This holds characteristic Carboniferous fossils, and indicates oceanic conditions of deposit. It is 500 or 600 feet in thickness, exceedingly hard and durable. Its position shows that at the time of deposition the area of the Hills was deeply sunk, because over a great part of the district this limestone lies horizontal on the horizontal Potsdam, and is nevertheless elevated above the edges of the slates and schists excepting on the very highest peaks. It has been raised without contortion, and shows only gentle dips around the margin of the Hill region.

VIII.

The incoming of sandstone near the close of the Carboniferous deposits indicates that some part of the Pre-Cambrian area had then risen above the water, and the lack of any decided break between the Palæozoic and the Mesozoic as well as the variation in the material of the Trias shows an unstable condition of level during that era. The Trias contains beds of bright red clay, a very pure 30-foot limestone, hard and uniform, and enormous strata of gypsum cropping out all round the hills in quantity sufficient to supply the whole continent. The limestone forms a

rampart through which the streams have cut narrow channels, by which entrance is with difficulty gained to the central fastness. A fine illustration of this structure is seen along the narrow-gauge railway running up Elk creek from Postville to Lead City.

Though the Jurassic beds that follow are conformable to the Trias, yet no greater contrast can well be imagined than that offered by these two formations. The former is absolutely destitute of all trace of life, while the latter contains some of the richest fossiliferous strata known anywhere on earth. What physical changes are indicated by this difference cannot now or here be discussed, but whatever they were, they permitted the abounding reptilian life of the Jurassic to invade the lifeless seas of the Trias. The rapid thickening of the former beds to the northwest, as pointed out by Prof. Carpenter and others, shows that the land whence they came lay in that direction, while the gypsum of the Trias would imply a closed sea and great evaporation.

The vast and varied reptile fauna now accumulated by Prof. O. C. Marsh, at New Haven, has been chiefly taken from the Jurassic of the region surrounding the Black Hills. Many of its members being in part or altogether terrestrial, indicate land at no great distance, and the Hills then probably rose as islands above the Jurassic waters.

Of this fact there is no room for doubt at the commencement of the Cretaceous era, for the fine conglomerate at its base owes its origin to the Pre-Cambrian strata of the axis. But the emergence was apparently only temporary, and was followed by subsidence, which again carried the Hills under water, and allowed the deposition of the later Cretaceous beds over the whole area. These strata indicate marine conditions, but no great distance from land, as they consist of clays and shale, with little lime, and contain abundant and beautiful specimens of Baculites, Ammonites, etc.

IX.

It seems probable that the Cretaceous sea continued on into the Eocene era, and that Eocene strata were deposited over the Cretaceous. As Prof. Carpenter has shown, there is evidently a gap in the record here. The Eocene is wanting in the Black Hills, and the Miocene lies immediately on the Cretaceous. During some part of this interval the central peaks, if not more, served

as distributing centres of the Pre-Cambrian rocks which lie scattered over the surface to the distance of 150 miles from the peak. They lie below the Miocene beds, and disappear under them at their first occurrence, and are even seen below their outliers.

The means and manner of the distribution of the boulders has been a matter of some speculation. Prof. Carpenter was once inclined to believe that they proved the occurrence of an Eocene ice-age, but has since abandoned that view. It is not easy, however, to see how such boulders could be scattered so far over the country merely by the ordinary agents of erosion.

The Miocene deposits were laid down in a great fresh-water lake, and in them are entombed the remains of a gigantic mammalia of that era, indicating the proximity of land. During all this time the Black Hills stood as islands in this lake, and were doubtless tenanted by the animals whose remains are found in the strata. Miocene deposits approach within 15 miles of the Hills.

Here the geological record of the region ends. With the exception of a few fragmentary notes of Quaternary time made by the usual stream erosion and of the relics of a few Pleistocene mammalia that occupied the Hills, the later annals do not exist. The great Ice-Age has left on the Black Hills no sculptured hieroglyphics of its ice-chisel, such as those that have immortalized it elsewhere. No erratic boulders, no arctic drift indicate an invasion by the northern ice, and no striation or grooving of the rocks leads to the belief that the Hills were an independent centre of glaciation. This fact is full of significance. Lying four hundred miles north of the southern edge of the great ice-sheet they were yet out of the zone of accumulation, and even beyond the zone of waste. The ice of the northeast and of the northwest expended its strength in crossing the wide prairie regions that separate these hills from the great glacial centres of the continent.

X.

But the chief interest of the region at the present time lies in the presence of the tin-ore mentioned at the outset of this paper. The economical importance of this mineral is greater than that of any other that the Hills are known to contain.

Cassiterite is usually limited to the proximity of granite rocks, but in the Black Hills it is yet more closely limited to the granite veins described above as occurring in the older schists. And in

these it is, as usual, very irregularly disseminated. Some veins are altogether barren. In others is found a varying quantity of ore, never very large. Strings and threads and granules, often almost invisible, with occasionally a lump weighing a few ounces, or more rarely a few pounds, are the forms in which the cassiterite occurs. This, it may be remarked, is the usual mode elsewhere. In some instances, and probably either in choice specimens or in chosen localities, a yield of three and even of four per cent., has been reported. But a sanguine estimate for the productive veins of the region could not exceed two per cent., and even this could only be reached by careful work and the rejection of poor material. The whole of the stanniferous material must be mined and picked over or crushed and washed in order to extract the ore, a process that entails considerable labor and expense.

It would be premature to give any positive opinion regarding the contents of the veins as they are followed down, but judging from indications there is no ground to anticipate any change. The weathered material on the hill-side is scarcely richer than the lodes, nor are the "streamings" to be compared in richness with those of some other parts of the world. Hence there is no reason to conclude that the portions of the veins already eroded were any richer than those now existing. Judging also from the arrangement and the structure of the veins they will run out downward as at the surface, and be succeeded by others, and they will certainly vary much in richness from place to place—a fact which always renders lode-mining an uncertain occupation.

There has been an immense expenditure of money during the past few years in the Hills, in mining machinery and other plant, and it is only reasonable to expect some return of metal from the outlay at no distant date. Enormous quantities of cassiterite undoubtedly exist in the granite in spite of its sparse and fine diffusion in the rock, but the problem awaiting solution is whether or not it can be concentrated and reduced at a figure that will afford a reasonable profit. It is too early at present to say what can be done with better machinery and methods, and the practice of the most rigid economy in the work. But the experience of a few years will show if the tin from the Black Hills can be produced at a figure sufficiently low to maintain itself in the open market of the world. If not, the subject of Dakota tin-mining will cease to be one of economic geology, and will become merely a question of the hight of the tariff-wall that can be built around it for its protection.

DISCOVERY OF A SECOND EXAMPLE OF THE MACROURAN DECAPOD CRUSTACEAN, PALÆOPALÆOMON NEWBERRYI.

R. P. WHITFIELD, New York.

The occurrence of decapod crustaceans in the Devonian, or Lower Carboniferous strata, is so rare that the discovery of an individual is well worth recording; and as *Palæopalæomon newberryi* is the earliest or first of the group yet known, its occurrence may well be considered as of special importance.

A few weeks ago I received from Dr. A. S. Tiffany, of Davenport, Iowa, under the name of *Echinocaris sp.*, undescribed, a fossil crustacean so badly preserved as to be somewhat misleading on first examination, but which, on being cleared from the rock in some of the critical parts, proved to belong to the genus *Palæopalæomon*, and so far as the specific features can be ascertained, to be identical with that species described in the *Amer. Jour. of Science, 3d series, 1880, Vol. 19, pp. 40-41*, and subsequently in the *Annals of the New York Acad. Sci., Dec., 1890, p. 505, Pl. XII, Figs. 19-21.**

The specimen is of about the same size as that figured as above, but much less perfect, as it shows only a part of the carapace, the right side and anterior end being quite defective. The basal joints of the antennæ shown in the first example are entirely absent in this one, and the first two segments of the abdomen, although present, are so crushed and folded as to be practically useless except to prove their existence. The other four segments are fairly preserved, and the central spine of the telson and right side of the flap are also tolerably well represented; while parts of several of the ambulatory feet can be detected at points in the rock.

No marked variation from the typical specimen can be found on this second example. The central or median ridge of the carapace is well marked, and the two halves are slightly disconnected along the posterior portion of its length; while the lateral ridge, or carination, shown on the type, is strongly marked on the left side of the present one, and appears as an elevated line, like a line of suture. There is also an area of depression extending from the

* Figures of this and several other crustaceous fossils were distributed on an albertype plate, with copies of the descriptions, extracted from the *Amer. Jour. Sci.*, early in 1881, to the number of 130 copies.

anterior margin, at the point of the lateral angulation, backward to the median line, at about half the length of the carapace, forming a large V-shaped depressed area over this part of the surface. The ornamentation has been only pustules and pits on the carapace and segments.

This specimen is said by Dr. A. S. Tiffany to have been found in the Kinderhook group at Kaskade, three miles west from the court house at Burlington, Iowa, in a forty foot bed of clay shale containing many nodules or concretions, one of which this has occupied. The type example of the genus and species above mentioned was found in a concretion, from the Erie shale at Leroy, Lake Co., Ohio, which is probably of the horizon of the Chemung group of New York, though this is not entirely settled.

PHYSICS OF MOUNTAIN BUILDING; SOME FUNDAMENTAL CONCEPTIONS.

T. Mellard Reade, C.E. F. G. S., Park Corner, Blundellsands, Eng.

One of the most frequently urged objections against the theory of mountain evolution with which my name is associated* is its supposed inadequacy to the production of the requisite lateral pressure. I hope to be able to show that much of this criticism is founded upon misapprehension; that it in fact gives more play in this direction than any other theory consistent with geological facts, at present in the field.

The fundamental idea underlying all these theories, and there are really very few of them, is that our globe is a cooling spheroid. It arises from this, that orographic changes can only occur from actual loss of heat by a part of the spheroid, or by redistribution of heat and pressure relative or absolute. These principles will become more obvious as we proceed in our inquiry.

Changes directly brought about by actual loss of heat, or what is called secular cooling, have formed the basis of a theory that has held the field for a very long time, and when we do not inquire too closely into the reasoning upon which it is founded, or indulge in quantitative investigation, it meets some of the first *a priori* conceptions of the sort of an agent required to effect the gigantic corrugations seen in some of the world's mountain chains. It has the merit of being a simple idea easily grasped, and the

*Origin of Mountain Ranges.

postulates granted, capable of doing an immense amount of work. The conception is now pretty generally recognized as founded on a fallacy, for the nucleus of the spheroid is not cooling, but only the outer rind to a very small depth while the shell itself is circumferentially contracting, except at the actual surface. The result *being, as I was the first to point out, that a much less thickness of the crust than was generally supposed is in compression. All this is matter of recent scientific history† but for the further elucidation of the position I have taken up in my "Origin of Mountain Ranges," I purpose showing that the secular contraction principle will only act as a mountain building agent—granting all the impossible postulates required for it—by an expenditure of heat and therefore initial energy out of all proportion to the work to be done.

In order to illustrate my meaning and to get the conception well into the minds of my readers, I will assume a hard crust forming a shell 20 miles thick of equal temperature throughout, resting upon a heated nucleus such as we suppose obtains at present in our globe. Assume that this nucleus, cooling only on the outer surface to a depth of a few hundred miles, loses sufficient heat without in any way changing the temperature of the enclosing shell, to produce a contraction of 550 feet of a radial bar cut out of the nucleus, then in consequence of the principle of cubical contraction the radius of the earth would be reduced by three times this amount or $550 \times 3 = 1650$ feet.‡ The hard shell unchanged in dimensions would have to fit itself to the reduced nucleus either by thickening or by corrugation. Let us assume the adjustment takes place by corrugation, then we shall have 1650×6.28 or 10,362 feet of surplus circumference to dispose of in folds measured in any direction over a great circle of the globe.

I have chosen the figure 550 for the purpose of easy comparison because that is the amount of linear vertical expansion that would take place in a crust 20 miles thick as assumed in our example§ raised 1000° Fahr. and is therefore an equivalent amount

*Origin of Mountain Ranges, Chap. XI.

†See Smithsonian Report. Record of Science for 1887 and 1888. McGee p. 240.

‡This is not obvious at first sight, but it arises from the circumferential stretching of the cooling outer layer over the uncooled portion of the nucleus.

§2.75 feet per mile per 100 Fahr.

to the heat lost to produce 550 feet linear radial contraction in a cooling globe.

Let us now examine the potency of the opposite principle of expansion which lies at the foundation of my theory. I have shown that if 10 miles of sediment were laid down on the crust of the earth, the underlying strata would be raised 1000° Fahr. in temperature by the rising of the isogeotherms, and the bottom layers of sediment to the same temperature gradually shading off to the normal at the surface. I have taken 20 miles in thickness of the under crust and overlying sediment combined raised 1000° Fahr. as representing my conception of the heating that would take place under the assumed conditions.

I must also ask my readers, to assume that instead of the heat being lost, equal to the production of such a contraction of the earth it is, by some non-conducting covering over the whole earth prevented from escaping into space. Under these conditions the heat from the nucleus would flow into the assumed shell 20 miles thick, until the temperature of the shell and the nucleus became equalized. Let us now consider what would be the effect on this shell when it was raised 1000° Fahr. in temperature, intercepting the precise amount of heat lost into space in the previous example.

It is evident, firstly, that if the co-efficient of expansion were the same at all temperatures in the shell as in the cooling mass it envelopes, the radius of the globe would remain the same, if we consider the radius as measured to the mean of the irregularities of the surface which would certainly come into being.

Secondly, though the cubic contents of the globe would remain precisely the same, the redistribution of heat within the mass would produce certain stresses and strains which we may easily picture to ourselves. The shell 20 miles thick, if it were possible for it to receive this accession of heat and sustain itself as a spheroidal shell, would increase in diameter. Taking the mean diameter of the earth, considered as a sphere at 7912.41 miles,* and the expansion 2.75 feet per mile per 100° Fahr., the mean diameter of the spherical shell would be increased $7912.41 \times 27.5 = 217.591$ feet $= 41.2$ miles. But it is evident that this could not happen, but that the shell must adapt itself to the nucleus, so leaving out of account for the present the contraction of the nucleus, which would be the same as in the first example, there will be a surplus

*Herschel. Outlines of Astronomy.

of 129.368 miles over every great circle of the sphere to dispose of in folds.

Thus we see plainly that with the same loss of energy by the nucleus, very different effects are produced; the interception of the heat otherwise radiated into space, would provide lateral pressure by expansion compared to lateral pressure by secular cooling in the proportion of 129.368 to 1.96, or in round figures 66 times as much. It is worth noting that any effect in corrugating the 20 miles shell produced by contraction in the first example would add to and intensify the effect in the second example.

These two comparisons are given merely as extreme illustrations to enable others to grasp the essential difference between expansion and secular contraction as mountain building agents—neither case is reproduced in nature, but both partially so. In place of the absolute non-conductor assumed to envelope the globe in the last example, put sedimentary deposits over a portion of it. Under these portions a re-distribution of heat occurs in precisely the same manner, though in less degree than in our example, for the sediments do not stop all the heat—only a portion thereof. The globe goes on losing heat as before, but much less under the sedimentary areas than where denudation is taking place, or where the condition of the crust is completely stationary, like in the non-sedimentary depths of the great oceans. It is to the relative distribution of heat in the earth and its crust that we must look for our mountain building agents and for the requisite stresses and strains. Some physicists, by a confusion of ideas, have supposed, that because there is no actual increase of heat under a sedimentary area simply through the raising of the isogeotherms, no mountain building can in this way take place. If the idea had been properly thought out the fallacy would readily have been detected.

I have dealt with this fundamental idea of the expansion of the crust through the interception of heat that would otherwise be wasted into space because it underlies my theory of mountain formation. I trust my readers will not therefore take this part for the whole of the theory for the rising of the isogeotherms is the *initiatory* precedent condition only.

I have described fully in my Origin of Mountain Ranges and in the outline of my "Theory of the Origin of Mountain Ranges by cumulative recurrent expansion" published in this magazine

Nov. 2, 1891,* the manner in which the internal forces of the earth are thus unlocked.

When we come to test physical theories by geological facts it is impossible to ignore the intimate relation that exists between sedimentation and mountain formation. It is quite unnecessary for me to dwell upon this in an American publication, for it is to the lasting credit of American geologists that they were the first to establish the fact, and no theory which does not take it into account as a *first principle* will ever be likely to establish itself as a reasonable explanation. This has been seen by many and from the time of Sir John Herschel down to the present, loading by sedimentation and unloading by denudation have been considered more or less a *vera causa*. It does not need deep thinking however to see that this can be but a partial explanation. It is a machinery that must in the absence of some other opposite force evidently come to an end—it must *run down*. Some of the geologists of the Indian Survey account for the supposed continued rising of the Himalayas in a similar way by the denudation of the mountains and the laying down of sediment on their flanks and on the Gangetic plain. At the best, whatever value we may be inclined to attach to the explanation, the Himalayas cannot have *originated* in this manner. It is not a theory of "*origin*" but of "*maintenance*" and the lateral pressure that it provides. is, compared with any form of the contraction or expansion theories, almost zero.

Mr. Fisher has lately introduced the conception of a fluid zone subject to convection currents. These convection currents flowing from under the crust under the great oceans are supposed to drag the crust towards the continents and to produce lateral pressure and mountain folding on their margins. Granting all the hypothetical conditions required—and this is granting a great deal—it is difficult to conceive how convection currents which can only originate from differences of specific gravity in the fluid itself, due to differences of temperature, could produce the necessary force, and still less, act continuously in certain directions through all the great time occupied in the building of a mountain range. A mountain range is too permanent a feature of the earth's surface to have originated or been maintained in this manner.

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*Originally published in the Phil. Mag.

But perhaps I am unable to do justice to Mr. Fisher's views as I feel insurmountable difficulties in looking at the problem from his standpoint.

We have now almost exhausted the catalogue of initiatory compressive agents invoked by various authors for the production of mountain ranges. It remains to consider a final one, namely, the intrusion of molten matter into the crust, and the detrusion and throwing back of the upper strata due to the forcing up of tongues or folds of the strata below. These agents can, however, be only secondary effects of expansion or compression, not initiatory forces. Nevertheless they play a very important part in the folding and building up of a mountain range which I have explained very fully in the "Origin of Mountain Ranges."

I trust I have now said enough to show that simple expansion by increase of temperature is by far the most potent of any known cause in the production of lateral pressure in the earth's crust. If to this we add recurrent expansion and the other agencies I have endeavored to show from geological and physical data are concerned in the building of a mountain range, we arrive at a satisfactory solution of the great problem of the folding and elevation of mountain chains.

Jan. 18, 1892.

NOTE ON THE OCCURRENCE OF ERRATIC CAMBRIAN FOSSILS IN THE NEOCENE GRAVELS OF THE ISLAND OF MARTHA'S VINEYARD.

By J. B. Woodworth, Somerville, Mass.

In the course of an examination of the dislocated Neocene* strata of the island of Martha's Vineyard, carried on under the supervision of Prof. N. S. Shaler, for the U. S. Geological Survey, during the summers of 1889 and 1890, I collected a number of chert pebbles from the white quartz gravel or "osseous conglomerate" of Gay Head, and from an outcrop of the same age in the village of West Tisbury. Several of these specimens proved to be fossiliferous: one from the locality in West Tisbury contains a fossil which, on close examination, is seen to be the zoantharian coral, *Ethmophyllum*, Meek, of the Lower Cambrian.

*Neocene is here used to designate the Miocene strata of Gay Head. See 10th annual Rept. U. S. Geol. Survey, p. 65.

The accompanying diagram, Fig. 1, represents a cross section of the coral, the outer wall, where wanting, being indicated by the dotted line. The fragment found is 6 mm. in diameter. Fig. 2 represents a longitudinal section of the inner poriferous structure.

This form bears a close resemblance to *Ethmophyllum whitneyi*, Meek,* except that the radiating septa meet the outer wall at a much less distance than in the figured specimens of this species. The number of septa is about the same, being at least 36. Some

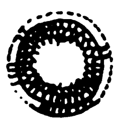

FIG. 1.

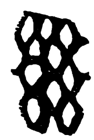

FIG. 2.

FIG. 1 is drawn twice the diameter.

FIG. 2 is about five times as large as as original section.

doubt is entertained as to the exact equivalency of the number by reason of the partial loss of the outer wall and some of the septa in the specimen.

The pebbles of chert from the osseous conglomerate at Gay Head show less clearly their organic contents, but coralline structure has been detected in a number of pebbles. Those containing fossils are of dark blue, almost black chert, are more or less rounded, smoothened and polished, and range in diameter from half an inch to pieces two or three times this size.

Occurrence of the Pebbles: These fossiliferous pebbles have so far been found by me only in the Neocene beds carrying the remains of Cetaceæ and sharks, and in the base of the overlying greensand in the places where the osseous conglomerate was partially or wholly reorganized in the deposition of the greensand. At Gay Head, the osseous conglomerate is on the average about one foot thick, but in West Tisbury it attains a thickness of at least two, and in some places, three feet, being apparently the fossiliferous upper portion of the white sands and clays which were deposited upon the plant-bearing Cretaceous beds described by Mr. C. D. White.† The number of these chert pebbles in the Neocene gravel beds is relatively small, the mass of the deposit being composed of quartz of vein origin. In the Gay Head sec-

*C. D. Walcott: 10th Annual Rept. U. S. G. S., p. 601, pl. LV.

†On Cretaceous Plants from Martha's Vineyard, *Am. Jour. Sci.*, (III) XXXIX, 1890, pp. 93-101.

tion, perhaps one per cent. of the pebbles in the osseous conglomerate are of chert.

Immediate origin of the Chert: The immediate source of these fossiliferous Cambrian pebbles is apparently to be found in the coarse sands and gravels underlying the Neocene formations. The age of these beds has not yet been definitely settled: They lie, unconformably, by slight erosion of their upper surface, below the marine Neocene or osseous conglomerate, and they overlie, without recognizable unconformity, the plant bearing Cretaceous beds which include the Gay Head lignites. On account of this apparent continuity of deposition succeeding the Cretaceous beds, the sands and gravels may tentatively be considered of the same age. No fossiliferous pebbles have as yet been

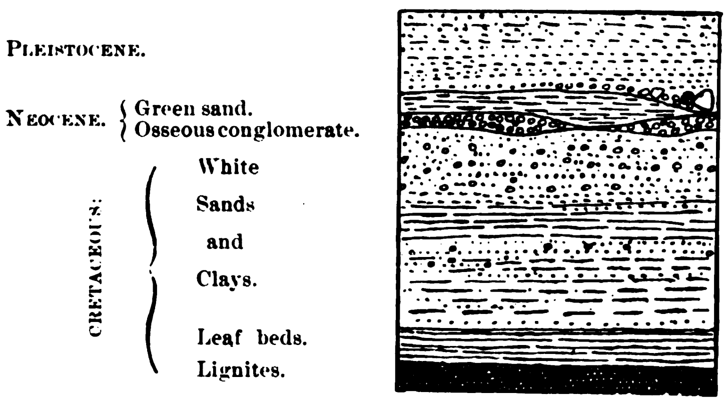

FIG. 3. Correlation section of the strata involved in the Gay Head dislocation, showing position of osseous conglomerate, and Cretaceous gravels.

found in the exposures of these Cretaceous sands and gravels, although they are probably present in these beds, as is shown by the consideration of the origin of the detritus in the osseous conglomerate.

The detritus of the osseous conglomerate appears to have been derived as follows: Sometime after the deposition of the Cretaceous sands, clays and gravels, the surface of this formation was exposed to ablation in a manner to assort out and carry further down the coastal slope much of the finer material, leaving behind after a short carriage, a stratum of coarse gravel of the thickness previously described. That this quartz pebble conglomerate at the base of the identified Neocene was derived from the underlying Cretaceous beds by a sifting process like that just appealed to, and not

by the erosion and deposition of fresh detritus from the granites gneisses, sandstones and other clastic rocks of the mainland. is shown by the fact that no decomposable rocks of feldspathic composition exist in the stratum. This view of the origin of some of the Tertiary and perhaps earlier Pleistocene gravels of New Jersey and Long Island has been advanced by Mr. N. L. Britton.*

It is possible to trace the quartz pebbles and associated cherts to a previous cycle of deposition, in which, before the making of the Cretaceous beds, the quartz pebbles with the cherts composed the finer, quartzose conglomerates of the middle and lower portions of the Narragansett coal basin. In the coal bearing section of these rocks, there occur numerous beds which, but for their consolidation and black color, closely resemble the Martha's Vineyard gravels, the thickness of which is explained by the extensive erosion of these antecedent Carboniferous beds.

Original source of the Cherts: The vein quartz in the Carboniferous appears originally to have come from the disintegration of a terrane thickly set with quartz veins, as Britton has suggested in the case of similar quartz pebbles in the coast plain of New Jersey; but the fossiliferous chert pebbles with identifiable fossils clearly point to a more definite association of rocks. Cherts naturally associate themselves with limestones, though rarely with sandstones, as in the Oriskany, and with shales; but the occurrence of chert pebbles in the lower Cambrian, siliceous limestones of Nahant, makes it seem probable that the Martha's Vineyard cherts were also derived from a calcareous section of the Olenellus Cambrian. As yet the nodules of the Nahant horizon have not been shown to carry Ethmophyllum and its congeners, yet Louis Agassiz,† in 1850, reported finding in them the structure of an *Astrea*.

The locality of lower Cambrian nearest to Gay Head is that of the red shales of North Attleboro,‡ a distance of fifty miles, but no nodules have been observed in the Attleboro section. That there is in the southern coast of Massachusetts or Rhode Island the seat of an extensive Cambrian section now concealed or removed by erosion, is shown by the abundant fragments of Cambrian quartzites found in the coarser conglomerates of the Car-

*American Naturalist, 1875, XXIII, p. 1033.

†L. Agassiz: Proc. Am. Acad, II, p. 270; also Proc. Boston Soc. Nat. Hist., III, p. 341, 1850.

‡N. S. Shaler: On the geology of the Cambrian district of Bristol Co., Mass. Bulletin Mus. Comp. Zool., XVI, 1888, p. 13.

boniferous, particularly on the southern border. These pebbles carry Lingulæ worm burrows, and more rarely pteropod casts. They have been found at Dighton,* Mass., in the Newport conglomerate by Dale;† I have found Lingulæ in a quartzite pebble in the red Carboniferous rocks of Attleboro, and they occur in the glacial drift on Gay Head, Martha's Vineyard, and Nantucket in great abundance. These quartzite pebbles however, do not occur in the Neocene gravels, their absence being apparently due to the relative ease with which their friable material has been reduced to sand in the repeated migrations of detritus which have determined the nature of the Neocene gravels.

The finding of these chert pebbles adds nothing to the evidence concerning the probable extent of Cambrian deposits in this part of the state at some time in the past, unless it be to indicate that we have to look for an extension of the Calcareous series which outcrops near Cape Ann,‡ at Nahant, and on Mill River, in Weymouth.§ The general trend of this formation in the direction in which we should expect to find the source of the chert pebbles is an incentive to more careful search, which it is the object of this paper to foster by calling attention to these less easily seen traces of the Cambrian sediments and fauna.

I am indebted to professor Shaler for kind permission to publish the notes concerning this collection of fossiliferous pebbles.

ISOBASES OF POST-GLACIAL ELEVATION.

By Baron Gerard de Geer, Stockholm, Sweden.

After the session of the International Congress of Geologists, last summer, in Washington, I made a journey of two months along the coasts of New England and Canada and inland along the St. Lawrence and Ottawa valleys, with the principal purpose of determining the limit of the Champlain submergence and the amount of the subsequent post-glacial elevation. The following is a brief outline of the results obtained:

Traces of sea action and marine deposits of Pleistocene age

*W. B. Rogers: Proc. Boston Soc. Nat. Hist., 1860, Vol. VII, pp. 389-91; W. W. Dodge, ibid, Vol XVII, p. 406.

†T. N. Dale: Proc. Newport Nat. Hist. Soc., 1884-5, Doc. 3, p. 9.

‡John H. Sears: Bulletin, Essex Institute, XXIII, pp. 12-16, 1891.

§Aug. F. Foerste: Proc. Boston Soc. Nat. Hist., XXIV, pp. 261-263; 1889.

above the present sea level were found only north and northwest of a line drawn from some point probably a little north of New York city to another between cape Cod and Boston and through Nova Scotia. In the northwestern part of Nova Scotia the limit of the uplifted marine deposits was found at a height of only about forty feet. Starting from this line the marine limit gradually rises toward the northwest, so that another line, called an isobase, drawn through points which have been upheaved 300 feet, passes probably from near Niagara falls by Albany, N. Y., and Augusta, Maine, to Moncton, N. B., whence it turns backward, running northwesterly and northerly, crossing the St. Lawrence estuary about half way between cape Gaspé and the Saguenay.

The 600-ft. isobase is probably to be drawn from Georgian bay past the outlet of lake Ontario, through the southern part of the Adirondacks, and thence east-northeast nearly to Moosehead lake. Here it makes an abrupt bend to the north and west, similar with the loop of the 300-feet isobase at Moncton, and runs first westward to some point not far from Three Rivers, and thence, turning again northeastward, it passes along the north shore of the St. Lawrence estuary. The highest directly determined point of the former shore line of the submerged area was near Ottawa, somewhat more than 700 feet above the sea level.

On the northern slope of the Adirondacks a gravel and sand deposit was found, which was evidently formed by a glacial river that probably owed its origin to the outlet of lake Iroquois, when that glacial lake had sunk from its highest stage and was drained between the Adirondacks and the shrinking land-ice. The level of the marine limit in the neighborhood shows that the post-glacial elevation there has been no more than three-fourths of the hight of the Iroquois beach.

When the ice-barrier of lake Iroquois was removed, it seems that the sea must have extended from the prolonged gulf of St. Lawrence by one branch into the Ontario basin; by another through the Ottawa valley and Lake Nipissing into lake Huron, unless that pass was still occupied by the land-ice; and by a third branch through lake Champlain down to New York, thus probably forming a strait in the Hudson valley.

The scarcity or absence of marine fossils in these branches or inlets of the sea is closely analogous with the conditions of the

much larger, brackish Baltic sea at the time of departure of the Scandinavian ice-sheet and also at the present day.

As to the extent and geological nature of the uplift, there is a very close resemblance between the conditions in North America and Scandinavia. In each country the maximum upheaval has taken place in the center of the old Archæan area of denudation which forms the nucleus of the continent, and at the same time is the tract where the load of the land-ice was heaviest. The amount of the upheaval and the ice-load decreased in the same directions. Thus the upheaval of the gulf of St. Lawrence was less than of the adjoining tracts on the south and north; and this accords with the observations of Mr. Chalmers, who has shown that the land-ice moved from all sides toward this depression, gradually thinning out there.

It is also to be remarked that the boundary of the uplifted area is pretty nearly coincident with the limit of the last glaciation.

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By John Eyerman, Easton, Pa.

Vertebrate Palæontology has lost one of its most eminent workers and authorities in the death of Joseph Leidy, M. D., LL. D. For the past forty years Dr. Leidy's papers on this subject averaged about six a year, many of these papers being memoirs of more than a hundred pages. Many tributes to his memory have been written, but the writer calls particular attention to the articles by Dr. Henry C. Chapman (Proc. Acad. Nat. Sci., 1891, pt. II, pp. 342-388), Dr. Harrison Allen ("Professor Joseph Leidy: His Labors in the field of Vertebrate Anatomy," Science 18, Nov. 13, p. 274) and No. 26 of this Bibliography.

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62. **Williams, H. S.**—On the Plates of Holonema rugosa. Abstract in Proc. A. A. A. S., 1890, p. 337.

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66. **Williston, S. W.**—The Skull and Hind Extremity of Pteranodon. Am. Nat., 25, Dec., pp. 1124-1126.

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List of New Forms, as Described in the Memoirs of the foregoing list:

Allops crassicornis **Msh.**	***Brontotherium beds, So. Dak.**	**†36**
Amia macrospondyla **Cope.**	**Oligocene, Canada,**	**17**
A. whiteavesiana **Cope.**	**Oligocene, Canada,**	**17**
A. maconnellii **Cope.**	**Oligocene, Canada,**	**17**
Ammosaurus **gen. nov. Marsh.**	**Triassic, Conn.,**	**36**
Anchisaurus colurus **Msh,**	**Triassic, Conn.,**	**36**
Anser condoni **Shuf.**	**Equus beds, Pliocene, Oregon,**	**58**
Aquila pliogryphs **Shuf.**	**Equus beds, Oregon,**	**58**

***Formation and locality.**

†Refers to number in memoir.

OBSERVATIONS ON LLAMA REMAINS FROM COLORADO AND KANSAS.

By F. W. Cragin, Colorado Springs, Col.

Restricting the genus, *Auchenia*, to llama-like forms having the premolar formula $\frac{2}{1}$, and considering that the dentition of *A. californica* (Leidy) is unknown, the transfer of *A. hesterna* (Leidy) to the genus, *Holomeniscus*, which Cope* has suggested on the ground of the probable absence of Pm. 3,† has rendered it doubtful whether any of the west American *Camelidæ* belong to *Auchenia* proper.

I am indebted to Mr. R. C. Hills, for opportunity to study the remains of a cameloid form obtained by him from volcanic ash-beds on a small tributary of the Huerfano river, in Huerfano county, Colorado. These remains, which are now deposited in the cabinet of the Colorado Scientific Society at Denver, include considerable portions of both maxillaries and mandibles and more or less perfect contained teeth, with various other parts of the skeleton, and pertain to a true *Auchenia*, the molar dentition presenting the formula Pm. $\frac{2}{1}$, M. $\frac{3}{3}$.

I was at first inclined to identify this *Auchenia* with *A. hesterna* Leidy; but geographical and some other considerations seem to render it more probable that Cope's identification of the maxillary in the Condon collection from the Oregon desert with that species is correct; and it is certain that that maxillary, as described, represents a different species from the Huerfano county *Auchenia*, whether Cope's inference of the absence of Pm. 3, and his consequent reference of the specimen to the genus, *Holomeniscus*, be justifiable or not.

The Oregon desert maxillary is described as having the Pm. 4 anteriorly attenuated, and this to such an extent as to render it "almost certain that there was no third premolar in front of it." In the Huerfano specimen, there is a well developed two-rooted antero-posteriorly elongate Pm. 3, while the large three-rooted Pm. 4 is two-rooted anteriorly and has its crown in the form of a quadrate prism, the grinding surface presenting a single large crescentic lacuna. In form, the third and fourth superior pre-molars thus have some general resemblance to those of *Procamelus occidentalis*.

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*Extinct Mammalia of the Valley of Mexico, p. 17.

†Inferred from the anteriorly attenuated Pm. 4 in a superior maxillary fragment from the Oregon desert, believed by Prof. Cope to pertain to *hesterna*.

In the Oregon maxillary, the posterior palatal foramen "issues opposite the fourth premolar's internal root." In the Huerfano specimen, it opens opposite the anterior part of the posterior root of the first true molar, or opposite the middle of the molar.

In comparing the Huerfano specimen with Leidy's type of *A. hesterna*, it will be noticed that the fourth inferior premolar in the former is, relatively to the adjacent first molar, larger than in the latter, and that, in form, it more closely approximates a triangular prism or wedge; features which are apparently only in part due to the somewhat more worn condition of the premolar of the Huerfano specimen, by reason of which condition, however, the lacuna of the grinding-surface is closed instead of being open posteriorly as in *hesterna*.

The strongly recurved posterior fifth lobe of the last upper molar, in the Huerfano specimen, is but moderately developed; for, though the tooth has reached a more advanced stage of wear than has the last *lower* molar of Leidy's type of *hesterna*, it does not contribute to the area of the grinding-surface, but becomes obsolete before reaching the plane of the latter.

Whatever may be the final generic disposal of the Californian *hesterna*, and of the Oregon desert maxillary, the present specimen is a true *Auchenia*. It lacks, however, the "compression-folds" seen on the lower molars of recent llamas. Its size was closely approximate to that of (*?Holomeniscus*) *hesterna*, from which the available data indicate that it is probably distinct. The species may be known as *Auchenia huerfanensis*.

I append the following measurements:

	Inches.
Mandible, from symphysis to posterior border (latter taken at three inches below infra-condylar hook)....	15.
Elevation of summit of coronoid process above inferior border of mandible..........................	12.
Depth of mandible at postsymphyseal constriction....	1.8
Same at posterior edge of alveolus of first true molar..	2.8
Inferior post-canine diastema......................	3.8
Antero-posterior diameter of grinding surface of second true molar..................................	2.
Transverse diameter of same	1.125
Antero-post. diam. grind'g surf. third true molar......	1.5
Transverse diameter of same.........................	1.18
Major diameter of acetabulum.......................	2.75
Minor diameter of acetabulum.................	2.5
Breadth of cannon bone at distal extremity...........	3.6
Length of first phalanx...........................	4.4
Breadth of same at proximal extremity..............	1.62
Breadth of same at distal extremity.................	1.25

Some cameloid remains obtained by Mr. E. D. Smith and the writer, from loess-marked volcanic ash-beds southwest of Meade Centre, Kansas, are also apparently referable to *Auchenia huerfanensis*. Most of these, including a second or third lower molar, vertebral and femoral epiphyses, etc., pertain to a young animal, but there is a proximal half of a first phalanx which, placed side by side with the first phalanx of the type of *Auchenia huerfanensis*, tallies with it perfectly in size and proportions.

A canine with gently curved, conical, and bicarinate crown, found with this phalanx, and which, therefore, may belong to the same species, or even individual, has the enamel thick and smooth on the outer, longitudinally grooved or striated on the inner face. The axis of its crown makes nearly a right angle with that of its root, indicating a long post-canine diastema. The two strongly compressed and elevated carinæ are formed largely (their crests entirely) of the thick enamel-layer of the outer face, and are inwardly recurved.

The length of the rectified canine, as preserved, is about two inches—to which perhaps a fourth of an inch should be added for the tip, which is broken off. The length of the root is 1.1 inch. The transverse diameter at base of crown is .4 inch; the antero-posterior diameter at same, about 5.5. The hight of the posterior carina at base of crown is about .1 inch, that of the (broken) anterior carina being apparently a little greater.

The capacious shovel-shaped crown of a lower incisor found with the preceding, and marked with a semicircular depressed area on the distal half of its upper face, may or may not belong to this or another *Auchenia*. It is a first or "pincer," canine, and its maximum or anterior width is .75 inch. The rather thick enamel of the front or lower face of this tooth is marked with fine undulating striæform grooves as in the incisors of the ox.

A cameloid metapodium from "old river gravel" at Denver, Colorado, and two first phalanges from the "Denver loess," collected by Prof. Geo. L. Cannon, indicate animals somewhat larger and stouter than those indicated by any of the remains above noticed, but which, as their teeth are unknown, cannot yet be determined.

The metapodium is 14.13 inches in length and, distally, 3.8 inches in breadth, the articular extremities, as well as the shaft, being stouter, in relation to the metapodium of *Auchenia huer-*

fanensis, than the relative breadths of the two specimens would indicate. One of the first phalanges has a length of 4.6 inches. a breadth proximally of 1.75 inch, and distally of 1.5 inch. The other, represented by the proximal half only, has a maximum breadth of fully 2.13 inches. These phalanges are not stout throughout, but expand somewhat suddenly from a comparatively narrow cylindrical shaft to the upper extremity.

The volcanic ash-beds which have yielded the type of *Auchenia huerfanensis* are regarded by Mr. Hills as Pliocene. Teeth of *Equus*, too much worn to admit of identification, occur in the same deposits, which in all probability represent the "Equus beds." But whether all of the so-called "Equus beds" belong in reality to one epoch, is a matter still to be determined.

In his monumental work on Lake Bonneville,* Prof. Gilbert has produced evidence which seems to definitely establish the fact that some of the "Equus beds" are Quaternary. On the other hand, Mr. Hills finds the ash-beds of the upper Huerfano drainage overlaid with a conglomerate which he provisionally believes to be identical with conglomerates not far distant, and which are overlaid by true morainal deposits.

The results of further field-work, which Mr. Hills hopes to prosecute in quest of the solution of the age of the Huerfano volcanic ash-beds, will be awaited with interest by all students of stratigraphic geology.

EDITORIAL COMMENT.

Progress of American Glacial Geology.

One of the most important contributions from American geologic exploration to stimulate similar research in Europe, is the tracing of the series of terminal moraines across the northern United States during the past fifteen years by Chamberlin, Smock, Upham, Wright, Lewis, Salisbury, Leverett, and others. The interest of Europeans in this class of drift deposits was greatly increased in 1886 and 1887 by the discovery and mapping of terminal moraines in England, Wales and Ireland, by the late Prof. H. Carvill Lewis, and in Germany by Prof. R. D. Salisbury. Another point in which Lewis was in advance of most of the

*Monograph I, U. S. Geological Survey, 1890, chapters VI and IX.

British geologists, is the origin of the shell-bearing drift deposits at high levels on Moel Tryfaen, and in other parts of northern Wales, Cheshire and Lancashire, which Lewis attributed, following Belt and Goodchild, to transportation by an ice-sheet which moved from Scotland and northern Ireland southward across the bed of the Irish sea. The work of glacial investigation by Lewis in England, which was left unfinished by his lamented death, has been taken up with earnestness by many workers under the name Northwest of England Boulder Committee, of which Prof. Percy F. Kendall, of Stockport, Eng., is secretary. In a paper before the Boston Society of Natural History, March 2, Prof. G. F. Wright described the work of this committee, and the admirable generalization of Prof. Kendall, now fully demonstrated, that wherever the shells, mostly fragmentary, are found in the drift at great elevations, there are also boulders from rock outcrops northward of the Irish sea, brought by the ice-sheet which gathered these shells from the sea bed. The "great submergence" of parts of Great Britain, which was supposed to have taken place during an interglacial epoch, is thus shown to be a needless and erroneous assumption.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Cause of an Ice-Age, by SIR ROBERT BALL, ROYAL ASTRONOMER OF IRELAND. D. Appleton & Co, 1891, pp. 180.

The discussion of the cause of an Ice-Age is prefaced in this little volume, by a brief statement of the records left by the ice, and by a statement of the nature of glacial and "genial" periods As indicated by the title, the vital part of the volume is the discussion of the cause of glacial climate. This discussion consists of a brief exposition of the astronomical hypothesis,—with amendment. Sir Robert's amendment to the astronomical hypothesis, as it has commonly been stated, may best be given in his own words, set in contrast to the general statement of the effect of varying eccentricity of the earth's orbit given by Herschel, and quoted by the author (p. 116). "'Supposing the eccentricity of the earth's orbit was very much greater than it actually is, the position of perihelion remaining the same, it is evident that the characters of the seasons in the two hemispheres would be strongly contrasted. In the northern we should have a short but very mild winter, with a long but very cold summer, *i. e.*, an approach to perpetual spring, while the southern hemisphere would be inconvenienced, and might be rendered

uninhabitable, by the fierce extremes caused by concentrating *half* the annual supply of heat into a summer of very short duration, and spreading *the other half* over a long and dreary winter, sharpened to an intolerable intensity of frost when at its climax, by the much greater remoteness of the sun.' "*

Sir Robert would modify the latter part of the foregoing statement of Herschel as follows: "In the northern we should have a short but very mild winter with a long but very cool summer, *i. e.*, an approach to perpetual spring; while the southern hemisphere would be inconvenienced and might be rendered uninhabitable by the fierce extremes caused by concentrating *sixty-three per cent.* of the annual supply of heat into a summer of very short duration, and spreading the remaining *thirty-seven per cent.* over a long and dreary winter, sharpened to an intolerable intensity of frost when at its climax, by the much greater remoteness of the sun." (p. 118.)

The new law which is thus announced is elsewhere stated as follows: "Under all circumstances and on either hemisphere 63 per cent. of the total heat of the year is received during summer, so that only the remaining 37 per cent. is left for winter. (p. 119.) * * * They (these figures) would remain the same however the dimensions of the orbit be altered, however its eccentricity be altered, or in whatever direction the plane of the earth's equator may inte rsect the plane of the earth's revo lution around the sun." (p. 121.)

The effect of this modification of the law governing the distribution of heat during summer and winter during varying eccentricities of the earth's orbit, cannot fail to greatly modify the conclusions as to the climatic effects which varying eccentricity is competent to produce. And the author does not fail to make the most of the situation.

It is calculated that during the time of high eccentricity when the summer lasted for 166 days and the winter for 199 (winter in aphelion), the ratio between the amounts of heat received daily in winter and in summer, is expressed by the figures .68 and 1.38. This difference, it is argued, could not fail to produce a glacial epoch. So sure is the author of his conclusion that he says, "perhaps it would hardly be an exaggeration to assert, that even if geologists had not hitherto discovered the Ice Age from its records on the globe's surface, astronomers would have demonstrated by calculation that Ice Ages must have happened, and would even now be urging the geologists to go and look for their traces." (p. 43).

Sir Robert dissents from some of the conclusions of Croll concerning the change in position which the gulf stream would suffer, "as a consequence of the transference of the glaciation from one hemisphere to the opposite." The doctrine of the recurrence of ice epochs, alternating with each other in opposite hemispheres, is a necessary result of the position taken by the author. The geological evidences of the truth or falsity of the hypothesis advocated, are not discussed.

Geological Survey of Kentucky; Report on the occurrence of petroleum,

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*Herschel.

natural gas and asphalt rock in western Kentucky, EDWARD ORTON, pp. 233, Frankfort.

Geological sections and maps. Report submitted April 2, 1891.

This report contains a review of the prominent theories of the origin of petroleum and natural gas, its geological relations, and the phenomena of the different oil fields, methods of utilization, its physical and chemical properties. It is based on the observations made by professor Orton in Kentucky, in the seasons of 1888 and 1889. The geological structure of western Kentucky is discussed, and illustrated by a section from Owensboro to Frankfort. This is followed by a brief history of the development of petroleum and its products in the state, included in the district reported on, each county or district being treated separately. It is a valuable report for the state, and will have numerous readers.

On the Lower Devonian Fish-Fauna of Campbellton, New Brunswick, by A. S. WOODWARD F. G. S., (Geol. Mag., III, 9, Jan. 1892, pp. 1-6)

The author describes a number of fishes which were collected during 1891. There are described one new genus, *Protodus*, which is named from detached teeth only, and is an elasmobranch, and three new species, *Protodus jexi*, *Diplodus problematicus*, and *Acanthodes semistriatus*.

On the Characters of Some Palæozoic Fishes, by E. D. COPE. (Proc. U. S. Nat. Museum, Vol. XIV, pp. 447-463, No. 866.)

This valuable paper is divided into seven sections, each complete in itself. In Part 1, Prof. Cope announces and describes a new elasmobranch genus from the Permian of Nebraska. The genus is named from a single tooth, which resembles in some respects Oxyrhina and Dendrodus. He thinks it belongs to a cladodont shark and has named it *Styptobasis knightiana*, after Mr. W. C. Knight, who found the tooth and determined the formation. *Styptobasis knightiana* "was a large shark of carnivorous habits and its presence indicates the existence of a marine fauna whose remains have not yet been discovered."

Part II. *On New Ichthyodorulites*, in which are described *Hybodus regularis* from the Triassic of Baylor Co., Texas, and *Ctenacanthus amblyxiphias* from the Permian of Texas.

Part III. *On the Cranial Structure of Macropetalichthys*. In this article *Macropetalichthys rapheidolabis* Owen is compared with Coccosteus, Dinichthys, etc. It is allied to Dinichthys and referred to the Placodermata (Arthrodira). "The general resemblance of Macropetalichthys to the Arthrodira renders it almost certain that it possesses a lower jaw and that it is a member of that order." In his synopsis of the families of vertebrata (Am. Nat. 23, p. 856), Prof. Cope included this order (Placodermi) in the Crossopterygia on the supposition that they possessed a maxillary arch and suspensorium. In a foot note to page 856 of his synopsis he adds: "The position of this order is not yet certain." In this present paper he announces that A. S. Woodward in his catalogue, has placed Placodermata in the Dipnoi, thus indicating the absence of maxillary arch and suspensorium. The structure of the skull of Macropetalichthys tends to confirm this. Newberry and others have allied Macropetalichthys to the sturgeons; the author concludes that the Arth-

rodira cannot be placed near the sturgeons on account of the structure of the pectoral fins, and the cranial structure which has no resemblance to that of those fishes.

Part IV. In this part is described the first known specimen of the pectoral spine, almost complete, of *Holonema rugosa* Claypole, from Mansfield, Tioga Co., Pennsylvania. The spine is without complete segmentation, differing in this respect from Bothriolepis and Pterichthys. The spine is continuous to the apex, thereby constituting a generic distinction between Holonema and Bothriolepis. Length 54 mm, base width 11 mm, middle 7 mm.

Part V. *On the Paired Fins of Megalichthys nitidus* Cope. In this paper, the author, after announcing the provisional withdrawal of his genus Ectosteorhachis (Megalichthys) (Proc. Am. Phil. Soc., 1880, p 56) gives a study of the paired limbs and concludes that it is probably intermediate between Ceratodus and Pterichthys and possibly Arthrodira. The limb structure does not resemble either Polypterus or Ceratodus.

Part VI. *On the Non-Actinopterygian Teleostomi.* This is practically the same paper which appeared in the Am. Nat., 25 May, 1891, pp. 479-481.

In Part VII the author describes two new species of Platysomidæ, *P. palmaris* from the Permian of S. Indian Territory and *P. lacovianus* from the Coal Measures of Mazon Creek, Ill.

Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio, and West Virginia. By ISRAEL C. WHITE. pp. 212; with a folded map, 10 other plates, and 152 figures of sections in the text. (Bulletin No. 65, U. S. Geological Survey, 1891. Price, 20 cents.)

The classification adopted in this report partly preserves the subdivisions and nomenclature of the Brothers W. B. and H. D. Rogers, adding thereto such new features as now seem necessary from the present wider and more detailed knowledge of the coal-bearing strata. The entire Carboniferous system of the Appalachian region comprises three grand divisions, founded on the conditions of their deposition. The lower division is exclusively marine; the middle division consists of shore deposits, interrupted by incursions of the sea, and includes the lower Coal Measures: and the upper division embraces only fresh and brackish water deposits, including the upper Coal Measures and the Permo-Carboniferous series of Dunkard creek. Professor White here describes the outcrops and stratigraphy of the five series into which the Upper and Middle Ca boniferous are subdivided. Many interesting questions in connection with this work are reserved for discussion when the remaining southern half of the Appalachian coal field shall have been more fully studied.

On a group of volcanic rocks from the Tewan Mountains, New Mexico, and on the occurrence of primary quartz in certain basalts. BY JOSEPH P. IDDINGS. pp. 34 (Bulletin No. 66, U. S. Geol. Survey, 1890. Price 5 cents.) The volcanic series of the Tewan mountains shows a gradual transition from rhyolites through andesitic rocks to basalts, ranging thus from one

extreme to another in mineral composition. "The whole series," according to Mr. Iddings, in his summary of this investigation, "is characterized by a variable amount of porphyritical quartz in rounded grains, which is very noticeable in some of the basalts. These quartzes are primary secretions or crystallizations from the molten magma, and exhibit no definite relation to its chemical composition, being present in or absent from rocks of similar chemical composition. Their production is to be referred to certain physical conditions attending some earlier period of the magma's existence. From analogy with the occurrence of iron olivine in rhyolitic obsidian, it seems probable that the formation of primary quartz in basalt took place through the influence of water-vapor while the magma was under considerable pressure."

On a late volcanic eruption in Northern California, and its peculiar lava. By J. S. DILLER. pp. 33: with seventeen plates, and four figures in the text. (Bulletin No. 79, U. S. Geol. Survey, 1891. Price, 10 cents.) Basalt enclosing abundant quartz grains, closely like that described by Mr. Iddings in the Tewan mountains, is found by Mr Diller to have been very recently erupted at the Cinder Cone, ten miles northeast of Lassen peak in northern California. An explosive eruption, ejecting bombs, lapilli, and volcanic sand, formed this cone about two hundred years ago, as shown by trees whose dead trunks still project through the lava that flowed out from the base of the cone before the explosive action ceased. Afterward a period of inactivity probably lasted a century or more, as shown by like deposits which overlie the volcanic sand and are covered by a second lava flow. The eruption of this latest lava occurred probably somewhat more than fifty years ago and was not accompanied by any explosive ejection of fragmental material, the cone being undisturbed except at the point on its side whence the molten lava issued.

The Cinder Cone rises very steeply to a hight of 640 feet and has an average diameter of 2,000 feet at its base and 750 feet across its top, beneath which the pit of its crater sinks 240 feet. The later lava, occupying an area three miles long and having an average thickness of nearly a hundred feet, was extremely viscous at the time of its eruption, and its cooling crust was repeatedly broken up by the moving mass beneath. Its surface therefore is composed of sharp, angular blocks, loosely piled together, which were shoved along as a huge stone pile.

The explosively ejected fragmental lava of the earlier eruption and both the earlier and later lava flows contain quartz grains, which frequently are so large and abundant as to give a porphyritic structure, though more generally they are small and inconspicuous. Their average diameter is about one-thirtieth of an inch, but very rarely they are found over an inch in diameter. All of them have been greatly modified, apparently by the corrosive action of the magma, and each grain is encircled by a shell of granular, acicular augite, which is separated from the quartz by a film of glass. The author concludes that the quartz became crystallized in the magma before its eruption.

This valuable paper is illustrated by numerous views of the scenery of Cinder Cone and its adjacent tracts of lava.

The relations of the Traps of the Newark system in the New Jersey region. By NELSON HORATIO DARTON. pp 82; with a folded map, 5 other plates, and 49 figures in the text. (Bulletin No. 67, U. S. Geol. Survey. 1890. Price, 10 cents.) The traps of the Triassic area in New Jersey are found to belong to two classes. The most important class comprises extrusive sheets or overflows, three of which constitute the Watchung or Orange mountains, curved in their outcrops on account of flexure of the enclosing strata. In the second class, comprising intrusive sheets and dikes, the Palisades, forming the west shore of the Hudson, are the most conspicuous example. Mr. Darton concludes that the eruptions producing the Watchung trap sheets were doubtless similar to those of some of the great lava-flows west of the Rocky mountains, which during the later Tertiary and Pleistocene periods appear to have welled forth from long fissures, without the formation of craters or the ejection of fragmental materials.

Earthquakes in California in 1889. By J E. KEELER. pp. 25. (Bulletin No. 68, U. S. Geol. Survey, 1890. Price, 5 cents.) This paper is a continuation of the notes of earthquakes in California to the end of the year 1888, previously published by Prof. E. S. Holden. It describes all the shocks felt at the Lick Observatory on Mt. Hamilton, with others occuring elsewhere, so far as known, in the state. Forty-one days during the year 1889 had shocks which are here recorded.

A classed and annotated Bibliography of Fossil Insects, pp. 101 —*Index to the known Fossil Insects of the World, including Myriapods and Arachnids.* pp. 744. By SAMUEL HUBBARD SCUDDER. (Bulletins 69 and 71, U. S. Geol. Survey. Prices, 15 and 50 cents.) The writings of more than five hundred authors are cited in the first of these papers, with concise descriptive notes. In the second, the bibliography of each known fossil species is cited in chronologic order. The Paleozoic, Mesozoic, and Cenozoic eras are taken up successively, and in each of these time divisions the principal classes are separately presented: but under each class the generic names, and under them the specific names, are arranged alphabetically.

On the Bear River Formation, a Series of Strata hitherto known as the Bear River Laramie. By CHARLES A. WHITE,—and *The Stratigraphic Position of the Bear River Formation.* By T. W. STANTON. (*Am. Jour. Sci.*, Vol. XLIII, Feb., 1892, pp. 91-115.)

These two interesting papers add another link to the chain of our knowledge of the age of the non-marine formations which were formerly grouped under the one name "Laramie."

Dr. White, in his paper of seven pages, gives a short historical sketch of the work that has been done on the Bear River formation, from its discovery in southwestern Wyoming, by H. Engelman in 1859, who, with

F. B. Meek, referred it on fossil evidence, to the Eocene Tertiary. From the above date to 1876, these beds were continuously designated by Messrs. Meek, Hayden and other western geologists as Tertiary, and then, on Mr. Clarence King's general map of the 40th parallel, they were included in the Laramie, where they have remained without question, except for a few lines in Dr. White's Review of the Cretaceous of North America, in which he comments on the peculiarity of the fauna, and states that pending investigations may show that the beds may occupy an altogether lower position than had heretofore been generally supposed. The result of these investigations is said to be "that the strata which have hitherto been known as Bear River Laramie, are not only not referable to the Laramie formation, but that they occupy a lower position, being overlain by marine Cretaceous strata, the equivalents of which are known to underlie the true Laramie."

In this connection it may be stated that the Canadian geologists have for some years been recognizing a series of fresh—or brackish—water sandstone terranes of a character precisely similar to the Laramie interbedded between typical marine Cretaceous shales of Montana or Colorado age. Of them the Belly River series has been traced northward from the international boundary line to the vicinity of the North Saskatchewan river; and the Dunvegan series has been found for a considerable distance on Peace river underlying marine shales holding characteristic Pierre (Montana) fossils. This latter sandstone series is also stated by Mr. J. F. Whiteaves in the report of the Canadian Geological Survey for 1879-80, pp. 115 B, and 119 B to contain a Cyrena (Corbicula?) "with outline very like that of C. durkeei of Meek" and Corbula pyriformis? from the Bear River series of Wyoming. Assuming these identifications to be correct we have in the far north an undisturbed sandy non-marine terrane intercalated in the marine Cretaceous shales, holding two of the same species of fossils as the Bear River formation, and occupying a position approximately the same or but a little above that assigned to it by Dr. White and Mr. Stanton.

Mr. T. W. Stanton, in his paper of eighteen pages, gives the stratigraphical evidence of the position of the formation as obtained from four typical sections in southwestern Wyoming, in all of which the beds are highly inclined, folded or faulted, and in places overlain by nearly horizontal Wahsatch Tertiary. Mr. F. B. Meek's original section on Sulphur creek is first given, and there it is shown not to be continuous from the Colorado subdivisions of the Cretaceous to the Bear River formation, as was originally supposed, but to include at least two sections of the latter terrane, between which lie beds as low down as the Jurassic, from all of which characteristic fossils were obtained.

Finally in a table of formations the Bear River is designated as a series of "very fossiliferous argillaceous and calcareous shale, alternating with thin beds of sandstone," and is placed between the "shales and coal-bearing sandstones" of the Colorado, and the "conglomerates and coarse sandstones" of the Dakota?

Notes to accompany a Tabulation of the Igneous Rocks based on the System of Prof. H. Rosenbusch. By FRANK D. ADAMS. (*Can. Rec. Sci.*, Vol. IV, No. 9, Dec., 1891, pp. 463-469, with table.)

In the present transition stage of petrographical classification, it is a difficult matter to lay before the student a scheme for the determination and classification of rocks in which their relations to each other as brought out by their mineral and chemical composition are shown clearly and concisely. Such schemes or tabulations are usually too much burdened with unimportant details and doubtful sub-divisions which only serve to confuse and bewilder those using them. In the table accompanying these notes, Mr. Adams has succeeded admirably in presenting a classification of the igneous rocks based on that of Prof. H. Rosenbusch of Heidelberg, which is very simple, and may be readily comprehended by beginners in petrographical work, whilst at the same time nearly all rock names of real importance are included in it.

The author points out that although there has recently been a strong tendency among petrographers to consider rocks from a chemical standpoint, yet a purely chemical classification presents many grave difficulties, and therefore that mineralogical composition, and structure must still play an important part in any scheme which is to be generally adopted.

In his table the igneous rocks are first classified in three horizontal columns, headed "Abyssal (Plutonic) Rocks," "Dyke Rocks," and "Effusive (Volcanic) Rocks," the characteristic structures of each of these groups being given.

The table is also divided into eight vertical columns according to the mineralogical and chemical composition of the rocks, headed, "Alkali Feldspar Rocks," "Alkali Feldspar—Nepheline (or Leucite) Rocks," "Leucite Rocks," "Nepheline Rocks," "Melilite Rocks," "Lime-Soda Feldspar-Nepheline (or Leucite) Rocks," "Lime-Soda Feldspar Rocks," and "Rocks containing no Feldspathic constituent."

The rocks are then subdivided according to their bisilicates and micas, further subdivisions being made in the more acid ones by the presence or absence of quartz, and in the basic ones, the presence or absence of olivine.

Briefly summarized the more important points to be noted in connection with the table are:

1. In a general way the classification is a chemical one, the rocks decreasing in acidity from left to right of the table. The principal exception is the Nepheline, Leucite and Melilite rocks.
2. Several of the rock groups are given positions which differ from those which they occupy in Prof. Rosenbusch's book, the object being to more clearly bring out their chemical relationships. As examples may be mentioned the Nepheline, Leucite and Melilite rocks, placed immediately after the Orthoclase Nepheline (or Leucite) rocks; the Diabases, here classed with the volcanic rocks; the Finguaites, Alnoites, and some of the Acmite Trachytes which will be found among the Dyke rocks.

   The Pyroxene rocks are separated from the Olivine rocks, and

erected into a new group—the Pyroxenites, a name given by the late Dr. Sterry Hunt to certain non-feldspathic rocks differing in origin but having a pyroxene as the principal constituent.

3. Several gaps in former tables have been filled in with recent discoveries, such as Malchite, a dioritic rock corresponding to Aplite; Iolite, corresponding to Nepheline Basalt, but containing garnet; Fourchite and Monchiquite Lamprophyric dyke rocks of the Theralite series.

Little stress is laid on the division of the Volcanic rocks into older and newer, but it is still retained. In the subordinate classification many names, based merely on structural differences in the rocks, have been omitted, *e. g.*, Nevadite, granophyric, etc. The typographical features of the table are excellent, the relative importance of the various divisions being clearly brought out by the use of several kinds of type.

Important rocks are indicated by heavy-faced type, and when a rock is a mere variety of the preceding one, the type is shifted to call attention to the fact.

The author draws attention to the fact that although Rosenbusch's group of the Dyke Rocks has called forth much adverse criticism, yet this group has certain claims for recognition, and it is therefore retained, the three series of "granitic," "granitic-Porphyritic," and "Lamprophyritic" Dyke rocks, into which it is divided, being separated in the table by spacing, not by lines.

In conclusion, the author acknowledges valuable help and suggestions received from Profs. Rosenbusch, Geo. H. Williams, and the late Dr. J. Francis Williams.

Report on the Sudbury Mining District, Canada. By Dr. Robert Bell, Assistant Director, Geological Survey. This report is the result of three years work by Dr. Bell, assisted by Mr. A. E. Barlow and others. It is accompanied by a fine map, geologically colored, covering an area of 72 by 48 miles, equal in extent to about four counties. In doing this geological work Dr. Bell and his assistants had not the advantage of a settled or surveyed region, but were obliged to do a large proportion of the topographical work as well, and to contend against the disadvantages of a difficult forest country. The map was compiled under the supervision of Mr. Scott Barlow, chief topographer, and is very finely executed.

The narrowest part of the great Huronian belt comes within this sheet, and is flanked on the southeast by true Laurentian gneiss, but on the northwest side this belt is bounded by a mixture of similar gneiss with great areas of granites and syenites. The Huronian rocks which are fully described, consist largely of graywackes, with and without included fragments and pebbles, and are generally heavily bedded, but frequently coarsely slaty. These merge into quartzites, which are also largely developed and associated with elongated masses of greenstones and thick belts of clay-slate. The series is shown to be largely of volcanic or pyroclastic origin.

In addition to the undoubted Huronian, there is within this district a

basin of rocks which may be of Cambrian age. They consist of dark argillaceous sandstones with some shaly beds, underlaid by several thousand feet of a remarkable volcanic glass breccia, replaced in some parts of its course by black slates. The breccia contains light-colored angular fragments which, under the microscope are seen to consist of silicified pumice, showing, in the most beautiful manner, rows of small vesicles as perfect as those in recent volcanic glass. This great band of breccia affords conclusive proof of volcanic action on a grand scale in these early geological times. At the base of the series is a band of quartzite-conglomerate with white quartz pebbles.

The celebrated nickel and copper deposits of the Sudbury district come within this area and are described by Dr. Bell. He gives the results of his investigations on the relations and mode of occurrence of these ores. They would appear to be always associated with the greenstones, and to be most abundant at the contact of these rocks with some other, especially where the contact is intersected by a line of dislocation or by one of the gabbro dykes, which are numerous in the district. The occurrence of gold, silver, lead and other metals is described, and assays for nickel and gold are given by the chemists of the survey.

There are four appendices: I contains a careful description of the microscopic and other characters of about fifty kinds of rocks from the district by Prof. Geo. H. Williams, of Johns Hopkins University. II gives the levels along the Canadian Pacific Railway and of the principal lakes. III is a list by the best authorities of 73 species of Lepidoptera, collected by Dr. Bell north of lake Huron, and IV explains the meanings of the Indian geographical names in the surrounding country. The report is illustrated by some fine photo-engravings.

LIST OF RECENT PUBLICATIONS.

II. Proceedings of Scientific Societies.

Trans. N. Y. Acad. Sci. Nov.-Dec., contains: On the Geological Age and Relations of the Potomac Group of Virginia and Maryland, J. S. Newberry; On the Microbe of Phosphorescent Wood, A. A. Julien; Note on Hydrazoic Acid, a new mineral acid, H. C. Bolton. *Jan.-Feb. No.* contains: --Monticellite, a new mineral, J. F. Williams; Recent Work in North American Mammalogy, J. A. Allen. *March No.* contains: Man of the Stone Age, F. Starr.

Trans. Canadian Inst., Oct., 1891, contains: Notes on Nickel, by George Mickle; Bone Caves, by Arthur Harvey; Gold and Silver in Galena and Iron Pyrites, by R. Dewar.

Jour. Elisha Mitchell Scient. Soc. for 1891. Part I., contains: The Alexander Co. Meteoric Iron, S. C. H. Bailey.

Proc. Calif. Acad. Sci. Vol. III, Part 1, contains: Notes on the Geology and Petrography of Baja California, Mexico, Waldemar Lindgren;

Eruptive Rocks from Montana, Waldemar Lindgren; Notes on the Subalpine Mollusca of the Sierra Nevada near Lat. 38°, W. J. Raymond.

Minnesota Academy of Natural Sciences. Bulletin No. 2, Vol. III, contains: The field of geology and its promise for the future, W. J. McGee; A check-list of the palæozoic fossils of Wisconsin, Minnesota, Iowa, Dakota, and Nebraska, Bruno Bierbauer; The deep well at Minneopa, Minn., C. W. Hall; Notes of a geological excursion into central Wisconsin, C. W. Hall; The Stillwater deep well, A. D. Meeds; The iron-bearing rocks of Minnesota, H. V. Winchell; *Cryptozoon minnesotense* in the Shakopee limestone at Northfield, Minn., L. W. Chancy, Jr.; A recent visit to lake Itasca, Warren Upham.

III. *Papers in Scientific Journals.*

Am. Jour. Sci. *Oct. No.* contains: Structural Geology of Steep Rock lake, Ontario, H. L. Smyth; Geological Horizons as determined by Vertebrate Fossils, O. C. Marsh.

Nov. No. contains: Report of the Examination by means of the Microscope of Specimens of Infusorial Earths of the Pacific Coast of the U. S., A. M. Edwards; The Tonganoxie Meteorite, E. H. S. Bailey; New Analyses of Uraninite, W. F. Hillebrand; The Tertiary Silicified Woods of Eastern Arkansas, R. Ellsworth Call; Occurrence of Sulphur, Orpiment, and Realgar in the Yellowstone National Park, W. H. Weed and L. V. Pirsson; Mineralogical Notes, L. V. Pirsson: Peridotite Dikes in the Portage Sandstones near Ithaca, N. Y., J. F. Kemp; New Locality for Meteoric Iron with a Preliminary Notice of the Discovery of Diamonds in the Iron, A. E. Foote: The South Trap Range of the Keweenawan Series, M. E. Wadsworth; Geological Facts noted on Grand River, Labrador, A. Cary.

Dec. No. contains: Percival's map of the Jura-Trias trap-belts of central Connecticut, with observations on the upturning, or mountain-making disturbance, of the Formation, J. D. Dana: Notes on a Missouri Barite, C. Luedeking and H. A. Wheeler; The Contraction of Molten Rock, C. Barus; Notes on Michigan Minerals, A. C. Lane, H. F. Kellar, and F. F. Sharpless.

Jan. No. contains: Theory of an Interglacial Submergence in England, G. Frederick Wright: Permian of Texas, Ralph S. Tarr: Chemical Composition of Iolite, O. C. Farrington; Relation of Melting Point to Pressure in case of Igneous Rock Fusion, C. Barus; Discovery of Clymenia in the Fauna of the Intumes censzone (Naples beds) of western New York, and its Geological Significance, John M. Clarke; New Meteoric Iron from Garrett Co., Md., A. E. Foote; Farmington, Washington Co., Kansas Aerolite, G. F. Kunz and E. Weinschenk; Skull of Torosaurus, O. C. Marsh.

Geol. Mag. *Nov. No.* contains: On *Pleuronautilus nodosocarinatus*, A. H. Foord: Contributions to Precambrian Geology, J. F. Blake; On Normal Faulting, T. Mellard Reade: Work done by Lobworms, C. Davison: On *Ammonites jurensis*, E. T. Newton: On Athyris læviuscula, Norman Glass.

Dec. No. contains: On *Olenellus callavei* and its Geological Relationships, C. Lapworth: Petrological Notes, W. M. Hutchings; *Pholidophorus germanicus* in the Upper Lias, Whitby, A. S. Woodward; Pseudotrionyx from the Bracklesham Beds, A. S. Woodward: Notes on *Stereodon melitensis*, J. H. Cooke.

American Naturalist, *Sept. No.* contains: A Reply to Prof. Marsh's "Note on Mesozoic Mammalia," H. F. Osborn.

Oct. No. contains: A Sketch of the Geology of South America, G. Steinmann; Notes on the Hearts of Certain Mammals, Ida H. Hyde.

Nov. No. contains: The Permian, Triassic, and Jurassic Formations in the East Indian Archipelago (Timor and Rotti), August Rothpletz; The Hat Creek Bad Lands, J. S. Kingsley.

Canadian Record of Science, *July, 1891*, contains: On a new Horizon in the St. John Group, by G. F. Matthew; On some Granites from British Columbia and the Adjacent Parts of Alaska and the Yukon District, by F. D. Adams.

Ottawa Naturalist, *Nov., 1891*, contains: Canadian Gems and Precious Stones, by C. W. Willmott.

IV. Excerpts and Individual Publications.

On some of the Melaphyres and Felsites of Caradoc, by Frank Rutley. From Quart. Jour. Geol. Soc. Nov., 1891, Vol. XLVII.

On a Spherulitic and Perlitic Obsidian from Pilas, Mexico, by Frank Rutley. From Quart. Jour. Geol. Soc. Nov., 1891, Vol. XLVII.

A New Locality for Meteoric Iron with a Preliminary Notice of Discovery of Diamonds in the Iron, by A. E. Foote. From Proc. A. A. A. S. Vol. XL.

The Trias of the Vale of Cleoyd Notes on a section of the Trias and Boulder Clay in Chapel Street, Liverpool. A Further Note on the Decomposed Boulder and Underlying Red Sandstone in the Chapel Street Section, Liverpool. By T. Mellard Reade.

The Cause of the Glacial Period and an Explanation of Geological Climates, by Marsden Manson. From Trans. Technical Society of the Pacific Coast, Vol. VIII.

V. Foreign Publications.

Föld. Köz. (Budapest) Vol. XXI, Nos. 6 and 7, June and July, 1891, (Supplement) contains: Die Bewegungen auf den Schemnitzer Erzgängen in geologischer Beziehung, Szabo; Mineralogische Mittheilungen, Zimányi; Über die gwei geologischen Karnten Rumäniens.

Annual Report of the Department of Mines, New South Wales, for the year 1890. Sydney, 1891.

Jahresb. des Vereins für Erdkunde zu Metz für 1890-91.

Trans. Leeds Geological Association. Part VI. 1890-91.

Gestreifte Magnetitkrystalle aus Mineville, Lake Champlain Gebiet. Staat New York, von J. F. Kemp. Sep.-Abd. aus "Zeitsch. für Krystallographie, etc.," XIX.

Über das transkaspische Naphtaterrain. Uebersicht der Geologie Daghestans und des Terek-Gebietes. Ueber das diluviale, arabokaspische

Meer und die nordeuropaische Vereisung. Beitrage zur Geologie des Berges Savelan im nördlichen Persien. Ueber die Thatigkeit der Schlammvulkane in der Kaspischen Region wahrend der jahre 1885-87. Beitrage zur Kenntniss der Erzlagerstälten von Moravica und Dognacska im Banat, von Hj. Sjogren. Sep.-Abdrücken. Jahrb. k. k. geol. Reichsanstalt 1886-87.

Den arktiska floran forna utbredning i länderna öster och söder om Ostersjöu, af A. G. Nathorst.

Wissensch. Veröff. Vereins für Erdk. zu Leipzig. I. Band contains: Beiträge zur Geographie des festen Wassers.

Annales de Géographie, publiées sous la direction de P. Vidal de la Blache et Marcel Dubois.

Anales del Instituto Fisico-Geografico Nacional de Costa Rica, 1889, par Prof. E. Pittier.

Annual Report of the Department of Mines, New South Wales, for 1890.

Bulletin de la Société Géologique de France, t. XIX, Oct., 1891, contains: Note sur l'Eocene tunisien, par M. Aubert; Note sur le *Tissotia tissoti*, par M. Douvillé; Un filon d'argile plastique, par M. Tardy; Note sur le Sénonien et en particulier sur l'age des couches à Hippurites, par M. A. Toucas; Sur la Géologie des environs de Moustiers, par M. Collot; Sur la situation des couches à *Terebratula diphya* dans l'Oxfordien superieur, à l'Ouarsenis (Algérie), par M. E. Ficheur; Notes sur l'histoire et la structure géologique des chaines alpines de la Maurienne du Brianconnais et des régions adjacentes, par M. W. Kilian.

VI. Scientific Laboratories and Museums.

Johns Hopkins University Circulars, No. 94; The Geological Excursion by University Students across the Appalachians in May, 1891, by Geo. H. Williams.

Bulletin of the American Museum of Natural History, Dec., '91, contains: Observations on some Cretaceous Fossils from the Beyrût District of Syria, with Descriptions of some New Species, by R. P. Whitfield.

Catalogue of the Michigan Mining School for 1890-91.

SUPPLEMENTARY LIST OF THE WRITINGS OF ALEXANDER WINCHELL.

(Continued from page 139.)

1852. Yellow Rain, proving it to be pollen of coniferous trees. (Alabama *Whig*, April, 1852.)

1852. Analysis of Artesian water. (Alabama *Whig*, Dec. 22, 1852.)

1852. Chemical examination of "Sandy Land" soil. (Alabama *Whig*, two articles.)

1859. On the Geological Position of the Brine Springs of Grand Rapids [Michigan]. (Grand Rapids papers, Oct, 1859.) This was the first correct announcement ever made on this subject.

1860. On the Salt Springs of Saginaw. A communication to the superintendent of the Saginaw Salt works (Saginaw *Enterprise*, Feb., 1860.)

1862. Is the brine at Bay City obtained from the same source as the brine at East Saginaw? (Saginaw *Courier*, July, 1862.) The first announcement that the Bay City wells are supplied from the conglomerate of the Coal Measures.

1863. How shall we perfect the Agricultural College? (Detroit *Advertiser* and *Tribune*, Feb., 1863.) Three articles advocating a more professional or special organization.

1863. Important railroad connections with Ann Arbor. (Mich. *State News*, July, 1863.) This advocated a line from Toledo to Ann Arbor, Holly and East Saginaw, fifteen years before it was finally completed.

1865. Draft of an act to provide for the completion of the Geological Survey. Passed the House, Feb. 10, 1865. Lost in the Senate.

1866. Report on the Bruce Oil Lands at Oil Springs, Canada West. With maps, and two articles contributed by him to the Chicago *Republican*, Jan. 17 and 20, 1866. Pamphlet.

1866. Petroleum in Middle Tennessee. (Pittsburg *Mining and Manufacturing Journal*, 7 Nov., 1866.)

1866. Christian Theology illustrated from Nature, (*Northwestern Christian Advocate*, Chicago.) A series of 22 articles, the first appearing, Jan. 2, 1867.

1867. Stromatoporidæ. (Proc. Amer. Assoc. 1866, Buffalo meeting.) [See notice of his geological publications in *Jahrbuch*, for 1867. pp. 99, 100, 101.]

1868. The Geological foundations of our state, (Detroit *Weekly Advertiser* and *Tribune*, 27 Nov. 1868. Daily do. 30 Nov.)

1869. Impending crises in Nature. (*College Courant*, July 12 and 17, 1869.)

1870. Brazil in the Reign of Ice. With Illustrations (*College Courant*, June 4 and 11, 1870.) Opposes the view of L. Agassiz that the valley of the Amazon was covered by a continental glacier.

1871. The mineral fertilizers of Michigan. Report Dept. of Agriculture, Washington, 1869.

1871. Geological history of Mammoth Cave. (Indianapolis *Daily Journal*, Aug., 1871: *American Naturalist*. Nov., 1871.)

1872. Kakistocracy, or Too much Popular Government. Lecture delivered at Mattoon, Ill. 4 Dec., 1871. (Mattoon *Journal*, 6 Jan., 1872.)

1873. Reason for the Faith. Baccalaureate address at Syracuse University. (Syracuse *Journal*, *Northern Christian Advocate*.)

1873. The German Gymnasium (*University Herald*, Oct., 31, 1873.)

1874. The Genealogy of Ships. (New York *Daily Tribune*, 16 July, 1874. New York *Christian Advocate*; *Golden Age*; New York *Independent*, etc.) Elicited a number of replies in the *Tribune*. An ironical *jeu d'esprit* directed against the assumption that succession and structural relation in a series of specific forms, is proof of genetic relation.

1874. The Battle Fields of Faith. A baccalaureate address delivered at Syracuse University, June 21, 1874. (Syracuse *Courier* and *Journal*, June 21; *Northern Christian Advocate*, 2 July, 1874.)

1876. The Beautiful. An address delivered before the State Female College, Memphis, Tenn., 14 June, 1876. (*Western Methodist*, 8 July, 1876: *Northern Christian Advocate*, July, 1876.)

1876. State and School. (New York *Daily Tribune*, 12 July, 1876.) A criticism of the address of Charles Fitch before the New York State Teachers' Association.

1876. Huxley in New York. A review of his three lectures, (*Christian Union*, 11 Oct., 1876.)

1877. On the Origin of Species.)Syracuse *Journal*, 20 March, 1877.) Eighth lecture of a series.

1878. The old age of continents. A University Lecture, (Syracuse *Journal*, 31 Jan., 1878.)

1878. Science gagged in Nashville, (Nashville *American*, 16 June, 1878.)

1878. Reply to the Nashville *Christian Advocate* (Nashville *American*, 19 July, 1878.)

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1878. Culture and Knowledge. Address before the Æsthetic circle, Syracuse, and repeated by request in the hall of Y. M. C. A., Syracuse, 14 Nov. 1878. (Syracuse *Journal*, 17 Nov., (1878, and many times reproduced in various parts of the country.)

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1884. Minor editorials. (*Index*, 6 Dec., 1884.) 1,814 words.
1884. Notice of Lowrey's Philosophy of Ralph Cudworth. (*Index*, 6 Dec., 1884). 281 words.
1884. The rights of Religion in School. (*Index*, 20 Dec., 1884.) 1,147 words.
1884. Evolution as a hobgoblin. (Index, 20 Dec., 1884.) 1,300 words.
1884. Minor editorials. (*Index*, 20 Dec., 1884.) 1,753 words.
1885. Have we any Scientific Literature? (*Index*, 3 Jan. '85.) 1,320 words.
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1885. The constitution of University authority. (*Index*, 17 Jan., 1885.) 1,417 words.
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1885. The decay of the land. (*Index*, 31 Jan., 1885.) 1,339 words.
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1885. Table for determination of minerals. (*Young Mineralogist and Antiquarian*, April, 1885.) 550 words.
1885. Continent building. (*The University*, 13 June, 1885.) 1,717 words.
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1885. Congratulatory address to Prof. Asa Gray. Adopted by the Senate of the University of Michigan. Published in the *Register*, Ann Arbor, with Dr. Gray's reply, 25 Nov., 1885.

CORRESPONDENCE.

Arrow Points from the Loess at Muscatine, Iowa.—The hills on which the city of Muscatine stands are covered with a very fine deposit of loess, which in some places must be nearly fifty feet thick. It is easy to find the border of this loess lake.

In this deposit have been found great quantities of land shells, several pieces of bones, the remains of at least two American reindeer, a considerable part of the antler of the elk or common deer, pieces of wood, etc., etc. For several years I have thought there ought to be found in this loess unmistakable evidence that men were here when the surface of this lake was nearly 150 feet above the present high water of the great river at our feet.

Much of the loess is excellent for making brick. At several points hills are for this purpose cut away, leaving banks sometimes more than

twenty feet high, of the finest loess. Recently I have been able to gather some information concerning relics of man from this deposit. Mr. Chas. Freeman, a brick-maker, says he took from the loess, on the north side of Eighth street, near St. Mathias church, at a depth of about twelve feet, an arrow point.

In answer to my questions he said it could not have fallen from the top, for he took it out himself and noted especially the print in the loess. There seemed to be no possible chance that it could have gotten there through a hole or crevice. The loess at this place is very fine-grained, of a yellowish brown color, exhibiting slight indications of strata. At another yard, about two blocks from the above, on Iowa avenue and Ninth street, this same gentleman was moulding brick in the old fashioned way. In thrusting the clay into the mold he felt something sharp, and an examination brought to light an arrow-point.

At first sight it would seem as if this find would have been worth little or nothing, but on cleaning the arrow point it was found to be largely covered with blue clay, quite different from the rest of the loess at this place.

A bed of this same blue clay was strikingly shown here about ten feet below the surface, showing that this arrow-point was well covered by this same clay.

I examined this bank, and unless the arrow-point could have been so covered in the process of mixing, it must have been originally buried in the blue clay, which is ten feet or more below the present surface.

In the suburb of this city, about one mile from where it enters the Mississippi, Mad creek has cut away a hill forming a bank forty to fifty feet high. At about twelve feet from the top is a bed of gravel and sand. In this gravel Mr. Joe Freeman, a young man in the third year class in our high school, found a considerable fragment of the tooth of an elephant. In this same bed I observed numerous flint chips. The upper portion of this hill is loess. At the foot of the bank the creek runs over an argillaceous or arenaceous limestone of Devonian age.

On both sides of the Mississippi in this locality on the most commanding bluffs are numerous mounds of earth, the work of men. These are believed to be very ancient. So far I have not observed mounds on the loess. May not these arrow or spear points mentioned above, have been made and used by the builders of these mounds? F. M. Witter.

The Serpentines of the Coast Ranges in California.—In a paper on "The Pre-Cretaceous Age of the Metamorphic Rocks of the California Coast Ranges," published in the March number of the American Geologist, Mr. Harold W. Fairbanks states that his view that the serpentine in the Coast ranges is an altered eruptive, is in opposition to the views of others who have studied those rocks, except those given in a few brief statements published in the Bulletin of the Geological Society of America, in 1891. He also states that professor Whitney and his assistants held that the serpentine is an altered silico-argillaceous rock, referring to Whitney's "Auriferous Gravels" in support of his statement. On turning to page forty-two of the last mentioned work, it

will be seen that I was considered responsible for most of the nomenclature of rocks mentioned in that volume, and that the results were not then fully published. At that time I was an assistant to professor Whitney, and therefore, with his other assistants, am held responsible by Mr. Fairbanks for the view which he has quoted. The results of my work were published in 1884, for the peridotities, in my "Lithological Studies." In this work there were described more or less altered peridotites or serpentines from Colusa county, in the Coast range, and from Inyo, Sierra, and Plumas counties in the Sierra Nevada. All these described specimens were considered to be more or less altered forms of peridotite, in proof of which eight colored lithographic figures were given. (See my "Lithological Studies," pp. 129-132, 142, 158, 189-192, plate 5, figures 1, 2, 3; plate 6, figures 3, 4, 5, 6; plate 7, figure 1.) It was also then stated that the microscopic and lithological characters of the Coast range peridotite and serpentines studied, as well as those from the Sierra Nevada, indicated that they are eruptive. I may also say that, so far as the specimens described by myself were concerned, the results obtained by me were accepted by professor Whitney in 1882 as satisfactory and conclusive. As I have never studied any serpentine that I considered otherwise than derived from the alteration of peridotite or some allied eruptive rock, Mr. Fairbanks' confirmatory observations are of very great interest to myself. M. E. WADSWORTH.

Michigan Mining School, Houghton, Mich., March 2, 1892.

ENGLACIAL DRIFT OF LONG ISLAND. In the December number of the AMERICAN GEOLOGIST, Warran Upham calls the attention of glacialists to certain criterea of englacial and subglacial drift.

In my study of the drift formations of Long Island, I had noticed a difference between the bottom and surface portions of unmodified till, but was never able to draw a line between them. Of course, when the two were separated by a layer of stratified material, the surface part could easily be recognized from the hardpan, but where this line of separation does not take place it is difficult to determine exactly where the one leaves off and the other begins. It is true, as Mr. Upham remarks, that the upper drift is yellowish in color, and is looser in texture than the hardpan, but the two blend into each other in such a way as to render a distinct separation impossible, and yet I am inclined to think that they are two distinct formations. One was laid down probably when the glacier advanced; the other was deposited when the ice sheet retreated. The surface drift is variable in depth, and there are sections where it is absent altogether or is only represented by a few large boulders: as at Rockhill, near Eastport, Long Island, where a huge erratic is seen resting on the stratified gravel, the finer material having been washed away. In general, however, this yellowish sandy boulder drift covers the surface of Long Island. It covers the hills as well as the depressions at Brooklyn, and large *niggerheads* are everywhere seen, where the lots are vacant, protruding out of the drift which is only a few feet in thickness. Along the line of the terminal moraine it is very much

the same, although not so determinable in places. It is very light on the Shinecock hills, for here the stratified gravel comes very near the surface. The bottom drift is also variable, and subject to many modifications.

The Rockaway Beach railroad, that cuts through the ridge north of Woodhaven, exposes an interesting section of drift. The moraine is broken up by old subglacial streams, and adjacent to these depressions, the material near the edges of the bank, show signs of stratification, but these stratified layers never extend clear across the cut except near the surface. In the center of the bottom part of the drift is a mass of boulders in a sandy matrix, and over this is the hardpan, which is also full of erratics. Then comes the modified drift, and over all the so-called englacial drift which probably was laid down after the floods had subsided. The modification of the drift at this point tends to prove, I think, that kettle-holes were in some way connected with subglacial rivers.

North of the terminal moraine the whole bottom part of the drift seems to be modified, although a small section was exposed at Ridgewood, where underneath some fifteen or twenty feet of stratified sand and gravel was a stratum of unmodified boulder clay of unknown depth, and there may be other sections like it that have not been exposed. Ridgewood, near Brooklyn, is situated near an old water channel that comes up through the Newtown creek depression. The under boulder drift was probably deposited when the ice-sheet lay over the island. The stratified sand and gravel tell the story of the floods during the melting of the glacier, and the upper deposit or englacial drift was laid down when the ice-sheet retreated. This upper drift thins out towards the depression showing that the floods must have prevailed while the deposition was going on. The waters must have receded, however, before the ice-sheet had disappeared, for the depression as well as the ridges are covered with unmodified boulder drift.

Professor Agassiz said: "All American drift is bottom drift." And in a sense this is true. I am inclined to think that the so-called subglacial drift is as much *englacial* as the surface portion of unmodified till, that is, both were held *in* the ice-sheet until deposited.

On Long Island as the glacier advanced from the main land the subglacial streams advanced with it, modifying the drift and carrying much of the detritus beyond the southern limit of the ice-sheet. The south side of the island is chiefly composed of this stratified material. These ancient streams can be traced by the depressions from the sound to the sea, and the upper deposit of unmodified drift that covers in general, the stratified deposits, shows, I think, that the streams were subglacial and not superficial. There is little direct evidence on Long Island of superglacial drift. The subglacial beds of stratified gravel are not so scanty as Mr. Upham supposes, for, as far as my observations go, they far exceed all other glacial deposits. The greater part of the terminal moraine, moraines of recession, or kame moraines, and the bottom part of the valleys and plains owe their modified condition to subglacial currents. I am aware that the terminal moraine is generally spoken of as being composed of unmodified drift. This is true of the surface part only,

for when broken into there are few places that do not show signs of stratification especially along old lines of drainage. On the extreme west end of the island where the flood of waters was great, nearly the whole of the morainic matérial is affected by it. The old subglacial channels are innumerable along the whole extent of the terminal moraine and the marginal kames and kame deltas were formed by the icy currents that issued from the front of the ice-sheet. Where the currents were strong the moraine is correspondingly broken, and the kames in front become more prominent as may be seen in the vicinity of Fort Hamilton and Greenwood cemetery. These marginal kames extend out for some distance from the ridge proper, and it is rather difficult to determine their exact southern limit, except by the slight covering of unmodified drift. I am inclined to think that the ice-sheet did not end with the so-called terminal moraine, for even the kame deltas that extend southward to the ocean are covered with a yellowish sandy clay, very much like the englacial drift referred to by Mr. Upham.

It is true, that the boulder line seems to end with the *marginal kames*, yet there is such a blending of the two, that no distinct line can be drawn between the marginal kames and kame deltas. The unmodified boulder drift covering the former would show, however, that the so-called englacial till extended farther southward than the subglacial till, in its unmodified form. It has seemed to the writer that these southern kames could not have been formed without the aid of an ice-sheet, and it may be that a study of this so-called englacial drift will lead to the solution of the problem, for this superficial depósit covering the plains on the south side of Long Island has never been satisfactorily explained. I made mention of it in my pamphlet on the formation of Long Island, published in 1885 and was unable to account for its origin. It still remains a puzzle, but I think we are getting nearer an explanation.

Eastport, L. I., Jan., 27, 1892. JOHN BRYSON.

PERSONAL AND SCIENTIFIC NEWS.

PROFESSOR G. FREDERICK WRIGHT delivered a series of ten lectures in Boston during February and March, on "The Antiquity and Origin of the Human Race," as one of the free Lowell Institute courses. The bearing of geology on this subject centers in the question, How long ago was the Glacial period? Professor Wright in reply accepts the conclusions of Prestwich, Gilbert, N. H. Winchell, and others, based on the amount of postglacial erosion of waterfalls, and on other evidence, which from many independent observations, computations, and estimates, give 7,000 to 10,000 years, more or less, as the time since the great ice-sheets of North America and Europe were melted away. Man was contemporaneous with the latest and maximum extension of the ice on both continents, as is known by his stone implements

in the gravel deposits formed by streams which brought this modified drift from the ice in which it had been enclosed as englacial drift. Under the lavas of Table mountain, California, and of Nampa, Idaho, the implements and other relics of men, and even their bones, including the famous Calaveras skull, have been found and assigned to a vast antiquity, but they may probably be no older than the latest general glaciation. The last great local accumulation of glaciers and ice-sheets on the Sierra Nevada and more northern parts of the Cordilleran mountain belt to Alaska is referred by Wright, as by Russell and Becker, to a subsequent time, during the Recent epoch. No proof of man's existence during even the later part of the Tertiary era has been obtained, and Prof. Wright believes that the evolution of the human race has been comprised wholly within the Quaternary era, probably occupying no more than 50,000 or 100,000 years. The substance of these lectures will be mainly included in a book entitled "Man and the Glacial Period," soon to be issued in the International Scientific Series, supplementing the author's previous work on "The Ice Age in North America."

PROF. EDWIN J. POND, OF THE U. S. COAST AND GEODETIC SURVEY, died in Washington in February, of scarlet fever. He was a young man of sturdy habits and a most earnest student of natural science, known to but a small circle of scientific people, owing to his modest demeanor, and his long residence in missionary labors in the education of colored youth in the remote south. An ardent student of geology and botany, he was a constant collector and contributor of data to others who published them. Although having resided in Washington but a short time, he had made many interesting discoveries in local geology. The writer first knew him in Texas, where, with his class of students, Prof. Pond discovered and collected the remarkable and as yet unpublished fauna of the Shoal Creek limestone, which he deposited in the National Museum. He published several short papers in Science on Texas geology. R. T. H.

THE SWISS COMMITTEE OF ORGANIZATION for the sixth session of the International Congress of Geologists has been constituted definitely as follows: E. Renevier, president; Alb. Heim, vice president; H. Golliez, secretary, and C. Escher-Hess, cashier; Dr. A. Baltzer, Dr. Ed. Brueckner, L. Duparc, Dr. E. Du Pasquier, Dr. Edm. v. Fellenberg, Dr. F. A. Forel, Dr. H. Frey, Dr. J. Frueh, Dr. U. Grubenmann, Dr. A. Gutzwiller, Dr. A. Jaccard, Dr. E. Kissling, Dr. Fr. Koby, Dr. F. R. Lang, P. deLoriol, G. Mariani, Dr. F. Muehlberg, L. Rollier, Dr. H. Schardt, Dr. C. Schmidt.

At a meeting held 28 Dec., 1891, this committee decided that the next session of the Congress will be held at Zurich, near the end of August or the commencement of September. The length of the session can be reduced to four days. One of these days,

at least, will be devoted to the meetings of the sections, in which questions of more special interest will be treated. There will be three sections, viz: 1. Mineralogy and petrography; 2. Stratigraphy and paleontology. 3. General geology.

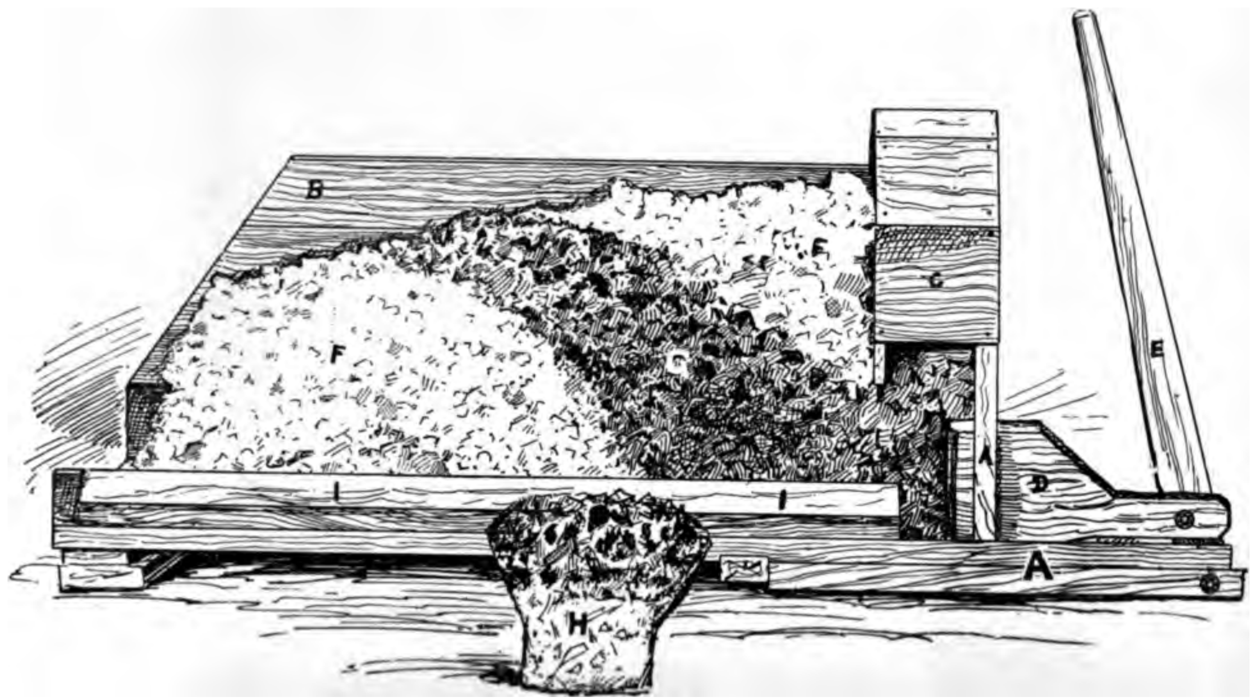
The committee intend to have two sorts of excursions, viz: Foot-excursions, and railroad and steamboat excursions. The former will be for the purpose of studying the geological features in trips across the Jura and the Alps, and would be suitable only for those accustomed to long walks. The second will be planned to enable the participants to see the principal classic regions in Swiss geology. By the time of the session it is expected that there will be a number of mountain railroads, which will enable the visitors to see some of the most elevated portions of the region. Excursions will also start, preceding the session, from different points, west or north from Switzerland, and will converge at Zurich. Also after the session other excursions will depart from Zurich, radiating through the Alps, and then will reunite at Lugano, where the Congress will finally close.

Suitable later announcements will be made, giving more details. It is evident that the Swiss Committee have entered upon their duties vigorously and in good season.

PRINCETON SCIENTIFIC EXPEDITION OF 1891. This expedition under Prof. Scott, explored the so-called Ticholeptus beds of the Deep River region, Montana, during the months of August and September and secured a large amount of valuable material. These so-called Ticholeptus beds which are lacustine, are comparatively limited in extent and lie between the Belt ranges. The beds lie uncomformably upon inclined Carboniferous (?) limestone and slates. Fossils were found in abundance at only two places. According to Prof. Scott, the Deep River beds are composed of at least two and perhaps three distinct horizons and in this respect he differs from Prof. Cope, whose list of species from this locality is misleading in the fact that the species are all grouped under one horizon. Prof. Cope, however, did not personally visit the locality. In the first horizon ten genera were identified; in the second twelve; in the third or top bed four. In all these beds there are still some genera to be identified. Prof. Scott comes to the conclusion that the Deep River (*Ticholeptus*) beds form a complete transition between the John Day and the Loup Fork.

MR. W. J. MCGEE, OF THE UNITED STATES GEOLOGICAL SURVEY, gave the lectures on *Geology* in series 8, in the course of public lectures of Columbian University, Washington. They were twelve in number, extending through January and February, 1892.

DR. E. W. CLAYPOLE, AKRON, O., gave a course of twelve geological lectures in March, before the Rose Polytechnic Institute at Terre Haute, Indiana.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THE

AMERICAN GEOLOGIST

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AN EXPERIMENT DESIGNED TO SHOW THE UPWARD MOVEMENT OF SUBGLACIAL DEBRIS.

By OSSIAN GUTHRIE, Chicago, Ill.

The following experiment was devised sometime since by Mr. Guthrie to show that subglacial material rises through the ice during its forward movement. Since the experiment has been referred to in this journal* as showing that subglacial material does have such motion, it has been deemed advisable to give an account of the experiment an equally wide distribution. The experiment of Mr. Guthrie was described in a paper entitled "The Lake Michigan Glacier and Glacial Channels across the Chicago Divide" presented to the Geological Society of Chicago, October 30, 1890. Ed.

A box was constructed 8 ft. long, 3 ft. high, and 10 inches wide, to represent a valley. The inclination of the box was slight, about six inches in the eight feet. The bottom of this box (large A in the cut) extended about three feet beyond the box at the upper end, for a fulcrum for the lever E. The box had no cover and but one end, (small A) which was designed to represent the upper end of the valley and also aid in applying the pressure required to move the ice. Through this head a slot or mortise was cut, 3x10 inches, through which the piston D moved; this head also formed one side of the hopper or chute G which extended from one foot above the top of the valley to the bottom. This hopper or chute opened into the upper end of the valley directly in front of the piston D to which, through the agency of the lever E, a total force of 1,500 pounds could be applied if necessary. The sides of the box were supported against the great pressure by several strongly bolted clamps. This box was then filled to the top with broken ice FF, and the

*AMERICAN GEOLOGIST, Vol. IX, March 1892, p, 187.

hopper was filled with a mixture of broken ice and red sandstone, about half and half in bulk. The sandstone gave the mixture a dark color, and also gave it a specific gravity much greater than that of the pure ice in the valley. The lever was then operated, and the hopper kept supplied with the mixture until it was forced up through the clear ice in the valley, as shown by the dark mass between FF in the cut. A freezing mixture was then applied to the sides of the box, and the whole covered with canvass and allowed to remain until frozen, when one side was removed and a photograph taken from which the cut was made. Three similar experiments had been made previously, with gravel and cement, all resulting the same.

The colored material introduced at the bottom of the upper end of the valley appeared at the surface of the ice with rounded front, "in true glacial style."

PRELIMINARY DESCRIPTIONS OF NEW BRACHIOPODA FROM THE TRENTON AND HUDSON RIVER GROUPS OF MINNESOTA.*

N. H. WINCHELL and CHARLES SCHUCHERT, Minneapolis.

Lingula riciniformis var. galenensis.

The conspicuous difference between *L. riciniformis* Hall, and this variety, is that the former is constantly two thirds the size of the latter, and that the greatest width is across the center of the length of the valves, while the variety is widest in the anterior third. In the Galena horizon at Oshkosh, Wis., this variety is not rare, and there attains twice the size of *L. riciniformis* Hall.

Plate XXIX, figs. 10, 11.

Formation and locality. Galena shales, north branch of the Zumbro river.

Lingula (Glossina) deflecta.

Shell medium size, subtriangular; lateral margins diverging more or less rapidly from an acute apex, to the broadly rounded and deflected anterior third. Shell substance thick, and marked by strong, irregular concentric lines of growth, between which are

*The designations of figures and plates refer to Vol. III of the Final Report on the Geology and Natural History of Minnesota. Advance prints distributed Apr. 1, 1892.

numerous finer ones. In a profile view the line of conjunction of the valves is more or less convex dorsally. Pedicle (ventral) valve flat or slightly concave along the center lengthwise, and strongly convex transversely.

Brachial (dorsal) valve strongly convex, both transversely and longitudinally. In the interior of this valve the cardinal margin is broadly flattened, striated, divided centrally by a well defined narrow depression which terminates at a point one-fourth the length of the shell from the posterior edge. Near the posterior end of the depression are faint traces of the umbonal scar. The vascular trunks are discernible on each side and anterior to the rostral depression; thence having the same curve as the outer margin of the valve, proceed* to a point somewhat beyond the posterior half of the shell, where they gradually converge and meet near the anterior margin. Vascular branches originate only from the outer side of the vascular trunks. There is no other species of Lingula from the Lower Silurian, with the peculiar deflected anterior portion of the shell so characteristic of this species.

Plate XXIX, figs. 15-18.

Formation and locality. Near the base of the Galena, near Fountain, and in the Hudson River, near Spring Valley, Minn.

Lingulasma galenensis.

Shell large, oblong; subpentagonal. Anterior margin slightly convex, somewhat produced in the center. This species differs from *L. schucherti* Ulrich, in that the brachial (dorsal) valve is deeper; platform and median septum shorter, and the crescent smaller. In the pedicle (ventral) valve the platform is also shorter and is of an entirely different shape. The muscular scars of this species are also more distinct, while the interior pedicle area is absent.

Plate XXX, figs. 1-4.

Formation and locality. Near the top of the Galena limestone, Bear creek, south from Hamilton, Minn. Also in the Galena limestone at Decorah, Iowa.

Strophomena septata.

This species seems to be a local development of *S. trentonensis* and so far as external characters are concerned no distinguishing features can be pointed out Compared with *S. rugosa* we find a still closer general resemblance, both externally and internally.

It can, however, be separated readily from both when the interior is shown, by the strong mesial septum of the pedicle (ventral) valve. This originates between the diductor scars and continues to increase in strength to near the anterior margin where it often coalesces with one or two of the vascular ridges. In *S. trentonensis* the thickening of the interior near the anterior margin of the pedicle valve is obsolete, or entirely undeveloped—which is another distinguishing feature. The cardinal processes in both these species are also more elevated, while the rostral thickening upon which it rests is less strongly developed than in *S. rugosa*. The septum of the pedicle (ventral) valve in *S. septata*, will also distinguish it from *S. incurvata*, in addition to its smaller size, and comparatively greater width than length.

Plate XXXI, figs. 1-3.

Formation and locality. Common in the upper third of the Trenton shales at St. Paul and Minneapolis, and at Pleasant Grove, Olmsted Co., Minn.

Strophomena planodorsata.

Large, semi-circular or sub-quadrate in outline, concavo-convex, wider than long, greatest width along the hinge-line or immediately in front of it. Surface with fine radiating striæ every other or every third one somewhat stronger than those intermediate, crossed by exceedingly delicate and closely crowded concentric lines, and towards the anterior margin by a few larger subimbricating lines of growth.

The size, large flattened area of the dorsal valve, and the subquadrate muscular area distinguish this species from all others of the *S. rugosa* type.

Plate XXXI, figs. 8-10.

Formation and locality. Hudson River group, Spring Valley; Iron Ridge, Wis.; Wilmington, Ill.

Strophomena scofieldi.

Shell small, semi-circular in outline, biconvex, with a more or less prominent fold and sinus toward the anterior margin; hinge-line a little shorter than the greatest width; area of pedicle (ventral) valve forming an angle of about 140° with the plane of the lateral margin, centrally occupied by a convex perforated deltidium; that of the brachial (dorsal) valve fitting closely against the other valve. Surface marked by numerous crowded,

rounded, radiating striæ, increasing in number by implantation, and from 110 to 120 along the outer margin in adult shells, crossed by delicate, crowded, concentric lines and a few coarser growth marks.

Brachial valve not deep, evenly convex or with a fold near the anterior margin. Cardinal area very narrow, and slightly reflexed. Crural plates prominent, very oblique, coalescing medially; upon this thickening at the base two low ridges originate which continue upward and outward into the small low cardinal processes, about one half of which is covered by the deltidium. Immediately underneath the crural plates are two pairs of small adductor muscular scars, separated by a low rounded and short septum which bifurcates anteriorly.

Pedicle valve somewhat deeper than the other, evenly convex or with a broad shallow sinus near the anterior margin. Hinge teeth prominent and joining with the outer elevated margin of the short, sub-oval muscular area. This area is centrally divided by a low ridge separating the two pairs of adductor and diductor scars.

This species is of the type of *S. sinuata* (James) Meek (Pal. Ohio, vol. 1, p. 87, pl. V, figs. 5*a* to 5*f*), but can be distinguished readily from that species by the smaller size and greater number of striæ, which is about 60. The profound fold and sinus, greater size and less numerous striæ of *S. sulcata* de Verneuil, will distinguish it from *S. scofieldi*.

Plate XXXI, figs. 17-20.

Formation and locality. Rare near the top of the Trenton shales at Minneapolis and St. Paul: common near the base of the Galena in association with *Clitambonites diversa* at several localities to the south of Cannon Falls.

Strophomena emaciata.

Shell small, depressed, biconvex, semi-circular in outline: hinge-line somewhat less than the greatest width of the valve. Surface marked by numerous angulated radiating striæ, increasing in number by interpolation, from 65 to 75 of the large and small ones along the anterior margin.

Pedicle valve depressed convex, sub-angulated medially, greatest point of elevation about mid-length. Cardinal area narrow, less than 1 mm. in width, strongly elevated with a very convex,

apically perforated deltidium, which is somewhat wider than long, and excavated posteriorly for the reception of that of the other valve.

Brachial (dorsal) valve nearly flat or slightly convex, with a shallow mesial sinus, having its origin near the beak and rapidly widening to the anterior margin, which is more or less sinuous according to the depth of the medial depression. Cardinal area linear with a short, broad deltidium partially covering the cardinal process.

This little species of Strophomena is separated readily from all other biconvex forms of this genus, in having a rapidly widening mesial sinus in the brachial (dorsal) valve, and the pedicle valve sub-angular along the median line, while in all other related species these characters are the reverse.

Plate XXXI, figs. 21-24.

Formation and locality. Near the base of the Galena, associated with *Clitambonites diversa*, south of Cannon Falls.

Leptæna charlottæ.

Shell small, transversely semi-oval, plano-convex, geniculate, with the sides slightly convex, and converging to the broadly rounded front, or drawn out tongue-shaped; hinge-line as long or somewhat shorter than the greatest width of the shell. Surface marked by fine, closely crowded, alternating striæ as in *Rafinesquina alternata*, crossed by exceedingly delicate concentric lines, and over the visceral disc of each valve by more or less continuous zigzag undulations or wrinkles.

L. charlottæ differs from any other American species of *Leptæna* in its zigzag concentric surface corrugations, and other minor features which can be seen more readily in the illustrations than by any written comparison. Plate XXXII, figs. 1-5.

Plate XXXII, figs. 1-5.

Formation and locality. Upper portion of the Trenton limestone and base of the Trenton shales in the Bryozoa layers at Minneapolis and St. Paul.

Plectambonites gibbosa.

Shell small, semi-circular in outline, strongly concavo-convex, wider than long, greatest width along the hinge-line. Surface very finely striate, with six or seven stronger striations on each valve, much as in *P. transversalis*.

Pedicle (ventral valve) very gibbous and sub-carinate medially;

lateral slopes rapid and slightly concave: greatest elevation about mid-length. Cardinal area strongly elevated, slightly concave, somewhat wider than that of the other valve; delthyrium about as wide as long, with a small deltidium in the posterior portion, and more or less occupied by the cardinal process and deltidium of the other valve. Teeth small, supported by strong dental lamellæ. Diductor muscle pits deep, short, strongly diverging and separated posteriorly by a small septum.

Brachial (dorsal) valve concave and closely following the curvature of the other valve. Cardinal area wide, flat, retrorse; delthyrium with a large, simple cardinal process more or less covered by a deltidium which is usually imperfect medially. Crural processes short and widely divergent. Adductor muscle scars broadly triangular in outline, lobate, with the outer margin strongly elevated.

The convexity of its valves, and the interior characters of the brachial valve will distinguish at once this species from *P. sericea* Sowerby and *P. decipiens* Billings. Plate XXXII, figs. 13-17.

Plate XXXII, figs. 13-17.

Formation and locality. Galena limestone four miles south of Cannon Falls, and at Mantorville, Minnesota.

Orthis meedsi.

Shell of medium size, suborbicular, in outline; biconvex; anterior margin broadly deflected dorsally; hinge-line about one-fourth shorter than the greatest width; surface marked by strongly elevated, sharply rounded striæ, from forty-five to seventy on each valve along the anterior margin, crossed by numerous thread-like lines of growth; striæ arranged in bundles of two or three, those of the pedicle valve bifurcating, while on the brachial valve an increase takes place by interpolation. Exfoliated specimens show two or three rows of small black spots terminating on the striæ, which may represent perforations in the shell substance.

Pedicle (ventral) valve slightly convex, with a broad shallow inus; cardinal area of moderate width; slightly concave, elevated beyond, or depressed below that of the brachial valve; delthyrium small, triangular; beak slightly incurved. Interior characters of the valve are like *O. pectinella* but less sharply defined.

Brachial valve strongly convex centrally, with the lateral posterior areas somewhat concave; cardinal area very narrow, slightly

concave, with a broad delthyrium, which is occupied in part by a striated cardinal process.

Plate XXXII, figs. 39-42.

Formation and locality. Top of the Trenton shales at St. Paul, in association with *O. pectinella* and variety *sweeneyi*. Cannon Falls, Kenyon, Fountain, and elsewhere in Minnesota; Neenah and Oshkosh, Wis.: McGregor, Iowa.

Orthis meedsi var. germana.

This variety is differentiated from the above species by the following characters: Smaller in size and squarer in outline: valves more strongly and evenly convex: hinge-areas nearly equally wide but narrower, with the beak of the pedicle valve slightly elevated beyond that of the brachial; pedicle valve with a slight, somewhat angulated fold, while the brachial; has a shallow but distinct sinus which originates immediately below the apex of the valve. These produce a slight sinuosity in the anterior margin, the direction of which is the reverse of that in *O. meedsi*.

Plate XXXII, figs. 43-45.

Formation and locality. Not rare in the Galena formation at a horizon which is about 30 feet above strata holding *Clitambonites diversa* at several localities south of Cannon Falls, near Kenyon and Fountain.

Orthis proavita.

Shell of medium size; subquadrate; hinge line equal to, or a little less than the greatest width of the shell; cardinal angles rounded or rectangular; sides gently convex and converging to a more or less flattened or slightly concave anterior margin. Surface marked by simple, sub-angular striæ having their origin at the apex of the valves or immediately below it, addition taking place by interpolation on the brachial and bifurcation on the pedicle valve; one to three striæ terminating on the cardinal margin on each side of the umbo; 36 to 42 in number on mature examples, crossed by a variable number of imbricating growth lines near the anterior margin. In some of the specimens the anterior margin is sharply reflexed as by old age.

Pedicle valve has an insignificant mesial-elevation. Area comparatively narrow: delthyrium broad, triangular, two-thirds occupied by the cardinal process of the other valve: beak somewhat incurved. Interior characters as in *O. subquadrata*.

Brachial valve more or less strongly convex, greatest elevation

about mid-length. A shallow, or sometimes well pronounced broad sinus is present, having its origin in the upper third of the valve. Area narrow, perpendicular or slightly inclined forward.

Differs from *O. iphigenia* Billings, in having the fold and sinus reversed, and less number of striæ.

Plate XXXII, figs. 51-58.

Formation and locality. Not rare in the upper portion of the Hudson River group at Spring Valley.

Zygospira uphami.

This species occurs in the Galena limestone about 50 feet above the layers holding *Z. recurvirostris* in abundance. Its general expression shows it to be a descendant from *Z. recurvirostris* but differing from it in its much larger size, stronger convexity of the valves and somewhat finer striæ. The last feature is more apparent than real, due to the greater size of *Z. uphami.* Some specimens from which the shell has partially been exfoliated, show the interior of the pedicle (ventral) valve to have a strong muscular cavity extending from the beak to about one third of the length of the shell. From the antero-lateral margins of the area originate two prominent, diverging ridges, probably the markings of the main trunks of the vascular system, which become obsolete near the front margin. The crural plates of the brachial valve are very strong, and at their bases coalesce with a stout but rather short median septum, upon each side of which posteriorly are situated two depressions of the adductor scars: the second pair undefined.

Z. uphami is the linking species between *Z. recurvirostris* and *Z. erratica* Hall, and *Z. headi* Billings. Its nearest relations are with *Z. erratica.*

Plate XXXIV, figs. 45-48.

Formation and locality. Middle of the Galena horizon at Weisbach's dam, near Spring Valley, and near Wykoff and Fountain.

Hallina, n. gen.

Shells small, articulate, rostrate, biconvex, semi-plicate. Pedicle opening bounded laterally by incomplete deltidial plates. Calcified brachial supports comparatively long, somewhat longer than one-half the length of the brachial valve, and in form much as in *Waldheimia.* The detailed structure of the articulating and

cardinal processes is unknown. In thin sections it is shown that the crural plates of the brachial valve do not converge medially and join with the posterior end of the median septum as in *Waldheimia*, but that they probably coalesce with each other; a median septum is not present. Muscular scars undetermined. Shell structure impunctate, distinctly fibrous.

Type. *Hallina saffordi*, n. sp.

Named in honor of the veteran palæontologist, of Albany, N. Y.

Hallina saffordi and *H. nicolleti* do not show a punctate shell structure, either in thin section or on the exterior surface of the shell. The rudimentary deltidial plates, absence of a median septum in the brachial (dorsal) valve, and the impunctate shell structure will distinguish *Hallina* from *Waldheimia* and related genera.

This is the earliest known terebratuloid genus, and it is represented by two abundant and widely distributed species

Hallina saffordi.

Shell very small, rostrate, regularly elongate, oval, striate and evenly bi-convex. Pedicle (ventral) valve somewhat more convex than the other; point of greatest elevation about mid-length, slightly carinated, but otherwise evenly convex in all directions. Beak strongly incurved, but not in contact with the umbo of the brachial valve, with a small pedicle opening which is partially surrounded anteriorly by incomplete deltidial plates. Teeth well developed and supported by delicate, strongly oblique dental plates; other interior characters undefined.

Brachial valve evenly convex with a very shallow sinus in the anterior half. Brachial supports straight from the crural plates for a short distance forward, then bending backwards and laterally, turn and proceed forwards a short distance beyond mid-length, and nearly parallel to each other, where they bend rather abruptly upwards, and medially join at a point which is at about one-half the length of the calcified brachia. Thin sections do not show strongly thickened crural plates, nor a median septum amalgamated with the former at the posterior end. There is probably a small cardinal process present.

Surface marked with from 15 to 20 subangular striæ, which terminate on the posterior third of the valve; no concentric lines

of growth observable. Shell structure fibrous and apparently impunctate.

Plate XXXIV, figs. 55-58.

Formation and locality. Common in the "Glade" limestone at Lebanon, Tenn.; also near the top of the Birdseye limestone at High Bridge, Ky.

Hallina nicolleti.

Shell small, rostrate, biconvex, oval or sub-circular in outline. Pedicle (ventral) valve convex; point of greatest elevation about mid-length, with a shallow, very narrow sulcus down the centre, bordered on each side with a low rounded ridge, which towards the anterior margin becomes more prominent. The antero-lateral limits of the shell may be smooth, or with as many as five low rounded plications or marginal undulations. Beak strongly incurved, and with a small, oval pedicle opening, bordered by rudimentary deltidial plates on each side.

Brachial (dorsal) valve evenly convex, and trilobed toward the anterior margin; in some specimens the lateral lobes may have as many as six low rounded plications along the front margin. Calcified brachial supports much as in *Hallina saffordi*, except that the outer bands are curved laterally, while the anterior, recurved portion is shorter. Articulating processes and muscular scars unknown.

Hallina nicolleti is an easily recognized species, in its small size and camarelloid exterior. It differs from *Hallina saffordi* in the fold and sinus, and the usually obsolete marginal plications. Its associated species are the same.

Plate XXXIV, figs. 59-62.

Formation and locality. Abundant in the upper third of the Trenton limestone at Minneapolis, Mantorville, St. Charles, Rochester and Fountain. Also at Decorah, in Iowa, and Beloit, Wis.

Rhynchotrema inæquivalvis var. laticostata.

In the shales of the lower portion of the Galena south of Cannon Falls *R. inæquivalvis* (= *R. increbescens*) often attains a far greater width than is usual for the species. The four plications of the fold are closely arranged, while the five or six on each side of it are spread out, and are therefore larger than in that species. The junction of the two valves along the anterior margin is also more largely flattened. These specimens if found alone would be

regarded at once as a distinct species. Their development begins in the upper portion of the Trenton shales, where specimens are occasionally picked up at St. Paul. It is, however, not until this species is found in association with *Clitambonites diversa* Shaler, that the variety becomes common and attracts one's attention. In the Trenton of New York and Kentucky occasional specimens are met with approaching var. *laticostata*, but none of them are so strongly transverse as the Minnesota individuals.

Plate XXXIV, figs. 26-29.

THE DRIFT OF THE NORTH GERMAN LOWLAND.

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Dr. Felix Wahnschaffe, of the German geological survey, has recently issued a small volume entitled "The Causes of the Surface Form of the North German Lowland."* As the title indicates, the volume is primarily geographical, but it discusses the geography of the area under consideration from the geological standpoint. The book is particularly welcome to American glacialists, since for the first time it presents in compact form the general conclusions which have thus far been reached in Germany in the field of glacial geology, and affords a convenient and adequate basis for a comparison between the corresponding phenomena of Germany and the United States. Most of the publications on the glacial geology of Germany, which have heretofore appeared, have been special reports on circumscribed areas. These publications have not been widely distributed, and are not so well known to American geologists, as could be desired. Dr. Wahnschaffe's publication will therefore be of great interest and service, since it will aid in correlating the phenomena on opposite sides of the Atlantic. It is the purpose of this article to review the salient features of Dr. Wahnschaffe's volume, and at the same time to make some suggestions concerning the correlation of German and American glacial formations.

The volume has many excellencies. The author's sense of proportion is good, and special points are not magnified at the expense of other equally important ones. The book does not attempt more than it accomplishes. In Germany, no less than in

*Die Ursachen der Oberflächengestaltung des Norddeutschen Flachlandes. pp. 166, Stuttgart: Verlag von J. Engelhorn. 1891.

America, there are many questions connected with the formations of the ice age, concerning which there is not unity of opinion, and individual opinions are held, with certainly not less tenacity in Germany than in America. It is a conspicuous merit of the volume before us, that the author has stated with much fairness and discrimination the conclusions of other geologists where they do not agree with his own. In his copious bibliographical notes, the author shows his intimate familiarity with the literature of his subject. This is true not only of German literature, but of that of other countries as well. Although we are compelled to dissent from some of the conclusions reached by Dr. Wahnschaffe, and although we could have wished a fuller discussion of some of the questions involved, the volume is nevertheless a very satisfactory discussion of the glacial formations of the area under consideration. The order of treatment is generally historical, so that the volume gives us a sort of history of the evolution of opinion concerning the glacial formations of the territory described.

The questions of glacial geology have been studied for the most part independently in Germany and in the United States. It is gratifying to observe how closely the conclusions arrived at by the geologists of the one country agree with those of the other. Yet there are some points of difference. In some cases these differences are hardly more than verbal, and yet these verbal differences have more than once given rise to misunderstandings and to controversy. In other cases the differences are radical. The differences in the Prepleistocene geology and topography of the ice-invaded territory of Germany and America may be largely responsible for the difference in the history of opinion in the two countries. The differences in the methods of work have likewise helped to develop diverse interpretations. It is interesting to note that the differences between the present conclusions of German and American glacialists are much less considerable than those of an earlier date.

Topography and Relief of North Germany due mainly to Drift.

Dr. Wahnschaffe devotes a chapter to the discussion of the relations of the Prepleistocene formations of north Germany to the present surface. His conclusion, which seems to be well founded, is that the relief and topography of north Germany are mainly due to the disposition of the drift formations. A table of deep borings extending through the drift into the Prepleistocene forma-

tions below, reveals the interesting fact that in many places the upper surface of the Prepleistocene formations is below the level of the sea. Were it not for the drift, a very considerable portion of north Germany would be covered by salt water. In several places where the depth of the drift is known, its lower surface is more than 100 meters below the level of the sea. In one place its lower surface reaches the astonishing depth of 169 meters below sea-level.

The disturbances of the Prepleistocene formations by ice-pressure during the glacial period are discussed. The conclusion is reached that such disturbances, resulting in the folding and distorting of strata, were widespread, but that they did not attain such proportions as to exert an important influence upon the geography of the region affected.

Thickness of drift. The chief interest in the book centers in the discussion of the glacial formations themselves. The thickness of the drift presents variations not less than those which characterize the corresponding formation in our own country. In many localities the depth of the drift is more than 100 meters. The greatest depth given is 171 meters, but even at this depth the bottom of the drift had not been reached at this locality. One hundred and seventy-one meters is somewhat more than the greatest thickness of the drift known to the writer in the United States. The average depth of drift on the north German "flatland" is probably greater than that over most areas of equal extent in our own country. This is no doubt in part the result of the softer character of the formations over which the ice there spread. They were more easily eroded, and to a greater depth were converted into drift.

At the beginning of the chapter which discusses the effect of the ice upon the geography of north Germany, the author reviews the history of opinion concerning the drift of Germany. This involves a review of the history of opinion concerning the glacial hypothesis, from the time when it was shown to be impossible, to the time when, in spite of its impossibility, it was demonstrated. This is not the first time that that which was believed to be mathematically impossible has proved to be true, particularly in geology. Concerning the application of mathematics to geology Dr. Wahnschaffe quotes approvingly the statement of F. von Richthofen: "Mathematical calculation is inclined to take too little

cognizance of the facts which are established by observation, and in their stead to start from premises which have nothing to do with the problem in hand. The result is that mathematics, by very painstaking methods, sometimes reaches results which are altogether without value for the explanation of the real relations of things." (p. 62.)

Striæ. One of the striking differences between the glacial phenomena of Germany and America is the paucity of striæ in the former country. The ice there invaded territory whose formations belong largely to the Cretaceous, Eocene and Neocene periods. They are unindurated and therefore not adapted to the reception and retention of striæ. These formations contributed generously to the drift, and were finally deeply buried by it, so that rock exposures are relatively rare. The strong contrast between the two countries in the matter of striæ can hardly be more forcibly illustrated than by indicating that within the space of ten pages the striæ of each known locality in Germany are not only mentioned, but discussed, as well as such other phenomena of glaciation,— planation, polishing, *roches moutonnées*, etc.,— as are intimately connected with striæ. Since striæ on bed rock, and their accompaniments were at the outset regarded as the most convincing proof of an ice sheet, and since the surface inferior to the drift in Germany is rarely exposed, and since these exposures are rarely of such material as to exhibit striæ, planation, etc., it is not strange that the glacier hypothesis did not find so ready acceptance in Germany as in our own country.

Till mainly subglacial. The till of Germany Dr. Wahnschaffe regards as almost wholly subglacial. While admitting the possibility of superglacial till, he does not regard it as having any considerable development in Germany. In this respect Dr. Wahnschaffe's opinion is sharply in contrast with that of some American geologists, who hold to the idea of very considerable thicknesses of superglacial till overlying the subglacial, and in consonance with the view of other American geologists who believe that superglacial material has but relatively slight development in our country. The reasons assigned (pp. 82-3) by Dr. Wahnschaffe for classifying essentially all the till as subglacial, would not be of force as applied to material transferred from a subglacial to a superglacial position, if such transference takes place. And such transference is assumed to be possible (p. 86). The

references cited in support of the position that subglacial material may become superglacial, are based on observations on existing Alpine glaciers. Here the supposed transfer of stony material from the bottom of the glacier to its upper surface is accompanied by conditions which would not exist, or which would not exist to the same extent in plane regions. I believe it is true that the transference of subglacial material to a superglacial position is facilitated by these conditions, if not entirely dependent on them.

The ice-sheet which invaded Germany had descended from a mountainous region. The ice-sheet which invaded the United States, while it descended from high lands, did not start from, or pass over, a region nearly so mountainous as that of Scandinavia, from which the German ice-sheet took its source. It would be expected therefore that Germany would be more favorable territory than the United States for the development of superglacial till, whatever the process by which it became superglacial. Under these circumstances it would seem that if any difference exist between the quantity of superglacial till in the two countries, Germany should have the more. Dr. Wahnschaffe's opinion as to the paucity of superglacial till in Germany is therefore significant, and is in harmony with the writer's opinion concerning the same sort of till in the United States.

The Ground Moraine. Dr. Wahnschaffe discusses the method of transportation and deposition of the ground moraine. The views of the various German Geologists who have expressed opinions upon the subject are cited and discussed. Heim is cited as holding the opinion that material can be carried forward beneath the ice only where and when it is frozen to the ice itself. Haas introduces variety, if not value, into the series of opinions concerning the method of deposition of the ground moraine, by supposing that wherever the thickness of the ice was considerable, its weight must have converted its lower portion into water, so that between the ice and the land surface beneath it there was a layer of water in which the deposition of the till took place, and that the ice really rested upon the land surface only near its margin where its thickness was not great. From this view Dr. Wahnschaffe dissents. He advocates the view—so far as the writer is aware the only one ever held by glacialists in America—that the ground moraine was accumulated gradually beneath the ice. The lower portions of any considerable body of till in any given locality, are therefore

older than the upper, by some short period of time, at least. In support of this position, bowlder pavements and isolated bowlders in beds of till are cited, whose upper surfaces were striated by the passage of the ice-current over them, after they had ceased to move. The only reference which Dr. Wahnschaffe makes to the amount of material which can be carried beneath the ice at any given time is the citation of Penck's opinion that till to the thickness of several meters may be carried beneath the ice at one time. We should have been glad of Dr. Wahnschaffe's opinion concerning the positions in which ground moraine material is deposited, with reference to the margin of the ice. But to this point we find no reference.

Two Glacial Epochs. The history of opinion concerning the unity or otherwise of the glacial period is discussed, though less fully than geologists could have wished. The meagerness of the discussion at this point is probably the result of the fact that the object of the book is primarily geographic, rather than geologic. Dr. Wahnschaffe believes that there were two glacial epochs, and most of the German glacialists hold the same view. The evidences cited for a bi-fold division of the drift, and therefore for two glacial epochs, are mainly (1) the existence of vertebrate remains in the beds of sand and gravel which separate beds of till in the vicinity of Berlin; (2) beds containing marine shells in like stratigraphic position at various localities in the northern part of Germany; and (3) diatomaceous earths, likewise between beds of till. Most weight is attached to the first line of evidence (p. 87). Dr. Wahnschaffe recognizes the possibility that the diatomaceous earths might have accumulated near the edge of the ice in situations temporarily abandoned by it, during the retreating phase of an oscillatory movement. Under these circumstances, the next advancing phase of the ice's oscillatory movement might bury the diatomaceous earths beneath a new bed of till. In view of this possibility Dr. Wahnschaffe points out the fact that these diatomaceous earths interbedded with till do not necessarily indicate an interglacial epoch. Neither does our author regard the deposits of marine shells as conclusive. Many of them are not known to be in the position in which they were deposited by the sea, and the various shell beds have not been correlated with each other with any degree of certainty. They appear to belong to more than one horizon. Those marine shell beds which retain the position

in which they were deposited by the sea, must mean a recession of the ice sufficient to allow the sea to occupy the area where they occur. But the question might be legitimately raised whether a recession of the ice no greater than these shell beds would necessitate, must necessarily be interpreted as proof of two glacial epochs. Such recession, particularly if of short duration, might be looked upon as no more than a great oscillation of the edge of the ice. The vertebrate remains in the sand and gravel layers between beds of till in the vicinity of Berlin, would seem to us to have the same significance as the shell beds. So far as these fossils indicate a temperate climate, their significance as indicating a genial interglacial interval, is increased. Dr. Wahnschaffe does not give the species represented in these fossil beds, nor does he indicate the climatic conditions to which they testify. But if we are rightly informed, they are fossils of species which do not indicate a climate of great severity. The abundance of terrestrial mammalian remains in the gravel and sand separating beds of till in certain regions, is perhaps more significant than the abundance of marine shells in corresponding situations, since the mammalian remains accumulate more slowly.

The evidences of more than one ice epoch which are most strongly relied upon by glacialists in America, are not brought out in the treatise before us. It would seem either that the evidences do not exist in Germany, or that they have not been made use of. The author does not indicate that there are in Germany (1) soils resting upon till or any form of older drift, buried by later glacial formations. He does not indicate that there are (2) beds of drift whose surfaces are much weathered and deeply oxidized, now buried by later drift deposits, whose surfaces are much less weathered and oxidized; nor does he, in this connection, emphasize (3) the difference between the amount of sub-aerial erosion suffered by the surface overspread with the drift which is regarded as first glacial, as compared with that suffered by the surface overspread with drift which is regarded as second glacial. In another connection, the fact is referred to that the lakes of Germany lie for the most part in and north of the Baltic ridge which crosses Germany in a course roughly concentric with the north German coast. This lake area lies wholly within the limits of the second glaciation, according to Dr. Wahnschaffe's interpretation, but the abundance of lakes in the Baltic ridge and north of it, is not

cited as evidence of the greater youth of the surface of this region. Nor does Dr. Wahnschaffe refer (4) to the more extensive disintegration of the bowlders of the drift in the southern part of Germany, as compared with that of the bowlders in the northern. Differences in the direction of the movement of the ice at different times, as indicated by differences in the direction of striæ, and especially as indicated by the different regions from which material was successively transported to a given region, also constitute a valuable criterion when taken in connection with the points above stated. In his chapter on striæ Dr. Wahnschaffe refers to the phenomena which indicate different directions of ice movement. But in discussing the question of two glacial epochs, these divergent movements are not made to support the theory of two ice epochs.

The foregoing are among the criteria which are especially relied upon in America as proving a recurrence of glaciation at widely separated intervals. We believe they are much safer and more widely applicable criteria than those given in the volume before us. My own study of the drift formations of Germany in 1887 and 1888 convinced me that the third and fourth points stated above are as well illustrated in Germany as in America. In my judgment they are of more significance as indicating a long interval between the deposition of the earliest and latest glacial formations in Germany, than all the fossil remains of whatever sort, which have yet been described.

Extent of Second Glaciation. As in America, the extension of the ice in Germany, in the second epoch, according to our author, was much less than in the first. The limits of the last ice advance however are still in doubt. It extended at least so far as to cover the eastern part of Schleswig-Holstein, Mecklenburg, a large part of Brandenburg, Pommern and East and West Preussen. While some of the German geologists would limit the second ice invasion in the western part of Germany to the lower course of the Elbe, Dr. Wahnschaffe believes that there is sufficient evidence that it extended further south. He finds traces of the work of the ice sheet of the second epoch in the vicinity of Magdeburg. He also believes that the bowlder-bearing sand which covers the "*Luneburger Heide*" southwest of the Elbe, is last glacial. The basis for this conclusion concerning the sand of the "*Luneburger Heide*" is not fully given. A single crossing of the

Heide in 1887 led me to the belief that the surface formation was not last glacial. But Dr. Wahnschaffe's conclusion doubtless rests on much fuller data than my own.

Nomenclature. The classification and nomenclature employed in mapping the drift of north Germany is so different from that to which the American geologists are accustomed, that both the maps and the accompanying descriptions are liable to misinterpretation unless one is familiar, in advance, with the exact meaning which is attached to each particular term. Many of the terms in use are the same as those employed in America, but the significance attached to some of them is altogether different. In America, for example, the term *upper till*—a most unfortunate name—is generally understood to mean englacial or superglacial till. In Germany, the same term (*oberer Geschiebemergel*) has a very different signification, and to one not posted concerning the technical meaning of the term, a most deceptive one. The term itself might suggest the till of the last glacial epoch as distinct from the till of greater age, but this is not its meaning, though no till is "upper" till (*oberer Geschiebemergel*) which is not of last glacial age. But not all of the till of the second glacial epoch is classed as "upper" till.

A mantle of bowlder-bearing sand frequently covers the till of the last glacial epoch. The same sand sometimes rests upon the older drift. Whether this super-till mantle covers second glacial till, or whether it rests upon the earlier drift where the later failed to be deposited or preserved, it is known as "upper bowlder-bearing sand" (*oberer Geschiebesand*), or, briefly, as "upper sand" (*oberer Sand*). If I understand correctly the meaning of the terms, the bed of till immediately beneath the "upper sand" is classed as "upper till" (*oberer Geschiebemergel*), if it be, or if it be believed to be, last glacial. The same bed or till, if not covered by the mantle of "upper sand," is likewise "upper till." The "upper till" of any given locality is therefore the uppermost layer of second glacial till, which there exists. If there be several layers of second glacial till separated by beds of sand or gravel, as is often the case, only the uppermost of these several beds is "upper till," while all the other layers of second glacial till are grouped with all the layers there may be of first glacial till, as "lower till" (*unterer Geschiebemergel.*)

Just as the uppermost layer of second glacial till in any place

constitutes "upper till" (*oberer Geschiebemergel*), so the uppermost layer of sand, if it overlie the uppermost layer of second glacial till, or if it be the stratigraphic equivalent of that which overlies the uppermost layer of second glacial till, is "upper sand" (*oberer Sand*). All second glacial sands which lie between beds of second glacial till, or below the lowest of them, are classed with first glacial and inter-glacial sand, as "lower sand" (*unterer Sand*). The infelicity of this classification and nomenclature is alluded to by Dr. Wahnschaffe, although it has been found to be a classification which is serviceable in mapping. Interpretations have changed since the existing nomenclature was adopted, but the nomenclature has not changed to correspond with the newer interpretations.

The "upper bowlder-bearing sand" often immediately overlies a layer of bowlderless, stratified sand, whose proper stratigraphic position is said to be beneath the "upper till." This stratified sand is not understood to be "upper sand." Because of this stratigraphic relationship, the bowlder-bearing sand at the surface is looked upon as the remnant of a layer of "upper till" which has escaped removal at the hands of glacio-natant and post-glacial waters, while the finer clayey parts of the till were carried away. In this case therefore the "upper sand" is a remnant of the "upper till" and is really its equivalent. We do not understand that the uppermost bed of till, lying below "upper sand," but separated from it by a bed of stratified sand, whose stratigraphical position is below the "upper till," would be classed as "upper till," even though it be the uppermost existing bed of second glacial till. The idea that the "upper sand" is a residue of "upper till," formed as indicated, seems to be a prevalent one. It is in this category that Dr. Wahnschaffe places the bowlder-bearing sand which covers the "*Luneburger Heide*." As already indicated the reasons given for such reference (p. 96) do not appear to me to be conclusive. Indeed none of the reasons assigned for believing that the ice, in its second invasion, crossed the Elbe in western Germany, seem to me to carry conviction.

Dr. Wahnschaffe, as well as other German glacialists, recognizes the fact that within the formations of second glacial age there may be, and in many cases are, several beds of till separated from each other by layers of sand and gravel. While American glacialists are fully agreed with Dr. Wahnschaffe that several

beds of till separated by layers of sand may arise within the period of one glaciation, we shall be likely to dissent from his implied (though not explicitly stated) conclusion, that every bed of sand interstratified with till, records a retreat of the ice, baring the surface on which the sand accumulated, and that each bed of till overlying such bed of sand, records a re-advance of the ice. I am not authorized to speak for American glacialists in general, but I hold it altogether possible that the deposition of till may be succeeded by the deposition of stratified sand, and this again by till, beneath the marginal portion of the ice, independent of any change in the position of the ice's edge. If each of the several layers of till which may locally alternate with sand were continuous over wide areas, and if the intervening layers of sand were also continuous over wide areas, oscillations of the ice margin would seem to best explain the phenomena. Dr. Wahnschaffe does not indicate whether or not this is the condition of things in Germany. It would be a condition of things most difficult of demonstration if true. From my acquaintance with the German drift, I do not think it generally true, and I see no reason for assuming an oscillation of the ice's edge for each change from ice to water deposition, within the body of the last glacial drift. It is not to be understood that the writer is arguing against oscillations of the ice's edge. Such oscillations, both seasonal and periodic, are believed to have occurred, and these oscillations may have given rise to many alternations of till and sand. But it is not deemed necessary to assume oscillations of the ice's edge to explain all alternations of till and sand.

Topography of the ground moraine. Two distinct types of topography are represented by the ground moraine, according to the volume before us. In the one case the surface is plain or but slightly undulatory, and more or less dissected by valleys, some of which are dry. Within those areas of ground moraine where the topography is of the plainer type, there are occasional sharp sinks of limited size, sometimes occuring singly, and sometimes in series. Many of these depressions have become the seat of ponds or bogs. Their existence is attributed to the action of water plunging down through crevasses from the surface of the ice, and wearing hollows in the land surface below.

The second type of topography which characterizes the ground moraine, as classified by the German geologists, is designated

"ground moraine landscape" (*Grundmoränenlandschaft*), the most characteristic feature of which is its "rapid changes of level" within short distances. This topography is further described as follows: "Between the numberless ridge- and mound-like elevations, which are altogether without order in their arrangement, e an equal number of depressions, giving to the surface a broken aspect. The elevations enclose countless roundish ponds and marshes, largely filled with peat and swamp deposits, as well as larger and more or less irregular swamps and lakes. This abundance of lakes and marshes is sometimes * * * * so great that upon the maps the till surfaces between them appear almost sieve-like." (p. 96.)

The region where the typical "ground moraine landscape" is best exhibited is stated to be along the Baltic ridge (p. 96), with which this type of topography appears in general to be intimately connected. It would appear from Dr. Wahnschaffe's description (pp. 97-8) that the constitution of the drift where this type of topography is developed is more sandy than is common to the ground moraine in other regions. The elevations within this Baltic ridge are said to be composed largely of sand and gravel over which there is frequently a layer of till.

In discussing the origin of the depressions which mark the "ground moraine landscape" Dr. Wahnschaffe follows his usual plan of giving the opinions of other geologists as well as his own. E. Geinitz would attribute them chiefly to the eddying action of waters during the time of the melting of the ice. Against this view Dr. Wahnschaffe argues that the depressions were already in existence at the time of the deposition of the uppermost layer of till, since this lines them and mantles the adjacent elevations. He maintains that their origin is therefore earlier in time than the melting of the last ice sheet. Upon the topography of the "ground moraine landscape" of the Uckermark, Dr. Wahnschaffe insists that the waters arising from the melting of the last ice-sheet had no considerable influence. In this view he is supported by Drs. Keilhack and Schroeder, and their position seems to be irrefragable.

The origin of the topography which has been designated "ground moraine landscape" (*Grundmoränenlandschaft*) has been much discussed by those who have had to deal with it. Various views concerning its production prevail. Among the factors

commonly believed to have contributed to its development, most of the German geologists appear to give a prominent place to ice-pressure, which is conceived to have bulged up drift material at the edge of the ice, producing hummocks and short, discontinuous folds. Dr. Keilhack places the development of the "ground moraine landscape" topography under consideration, beneath the oscillating margin of the ice, at the time when this margin stood along the line of the Baltic ridge, during the last glaciation. He ascribes it to the unequal accumulations of drift beneath the margin of the ice, and to the irregular bulging of the drift, effected by the pressure of the ice. Similar topography north of the Baltic ridge, is believed to have been produced in the same manner, at a later time, when the edge of the ice had receded to the position where such topography occurs. Schroeder is quoted as advocating the view that the peculiar topography here described was developed beneath the ice during the time of its slow retreat (p. 98); but whether beneath the margin of the ice, or remote from it, or whether the peculiar topography is the result of unequal accumulation or of ice-pressure, is not indicated.

Dr. Wahnschaffe believes that the "ground moraine landscape" was developed beneath the ice during its advance in the later ice epoch, and that the topography thus developed was not materially altered during the final retreat of the ice over the same region (p. 100), although the ice edge remained stationary on the ridge for some considerable period during its retreat. It is to be borne in mind that the topography here described is best developed along the "Baltic ridge," which is in a general way concentric with the shore of the Baltic. Dr. Wahnschaffe sees much significance in this position. He points out the fact that this sort of topography stands in a similar relation to great basins in various other parts of the world. In northern Italy, ridge-like belts of drift with a similar topography, border the Italian lakes on the south. In the Bavarian Alps similar ridges of drift rise higher than the basins enclosed within them. More conspicuous examples of the same relationship in America are referred to, where thickened belts of drift (our terminal moraines) exist, in a general way concentric with the Great Lakes of the interior.

Dr. Wahnschaffe's conception of the relation of the Baltic ridge to the Baltic sea, is something as follows: The ice starting from the Scandinavian mountains descended into the Baltic basin

and filled it. As it advanced to the southward, it rose from the basin of the Baltic onto the higher land to the south, carrying with it much material which it had scooped out of the basin, and especially, much that it gathered from the southern slope of the same, during its ascent to the land beyond. As the ice pushed out upon the land with its great load of debris thus acquired, its velocity was diminished. Where the greatest retardation took place, there would be the most extensive accumulation of glacial debris (p. 102). The site of this retardation and consequent extensive accumulation is marked, according to Dr. Wahnschaffe, by the Baltic ridge, which indeed owes its existence largely to the accumulation of drift brought about in this way. The "ground moraine landscape" is associated with the ridge, and is, according to Dr. Wahnschaffe, the result of this peculiar method of drift accumulation, for where the drift accumulation was greatest, there would it be piled up in rough topographic forms. The author sees no insuperable difficulty in believing that this sort of topography, developed beneath the advancing ice sheet, could be subsequently overridden by the further advance of the ice, without being destroyed.

From Dr. Wahnschaffe's view concerning the origin of the "knob and basin" topography of the Baltic ridge, we are compelled to dissent. According to his view the last ice sheet advanced far beyond the Baltic ridge, at least as far as Magdeburg. If this opinion be correct, the Baltic ridge must have been buried under a very great depth of ice. The Baltic ridge is a very conspicuous ridge. In many places its topography is very rough—of the pronounced knob and basin type. To suppose that glacier ice buried and overrode such a ridge with such a topography to such a depth as must have been if the ice advanced so far south as Magdeburg, is to attribute to the ice a degree of plasticity which we are not prepared to admit. It seems to the writer that Dr. Wahnschaffe's position practically denies to glacier ice much power of erosion, even when overriding to great depth the rough surface of a conspicuous ridge, composed of loose sand, gravel, and till, while it attributes to the same ice extraordinary power of erosion in passing through the Baltic basin, a little further north. The depth of the ice in the basin was of course greater than that of the ice which passed over the ridge, and in its erosive action in the basin it possessed whatever advantage comes from increased

thickness. We are prepared to admit that the same thickness of glacier ice may effect very different amounts of erosion in different regions; but we are not prepared to admit that a rough ridge of loose materials, standing squarely athwart the direction of ice movement, would constitute a belt where the erosion would be slight, if the ice passed over it in any considerable thickness. Dr. Wahnschaffe does not deny eroding power to the ice. Against such a view the great body of drift which covers north Germany stands as an unimpeachable witness. But his conclusion concerning the origin of the topography of the Baltic ridge seems to us to necessarily imply that the ice sheet which buried the ridge, and advanced many miles beyond it, was here essentially impotent, so far as erosion is concerned.

From what has preceded it will be seen that the "ground moraine landscape," arranged as it is in a great belt stretching across Germany, corresponds with the terminal moraines of North America. The constitution of the drift where this topography prevails, confirms this correlation. This relationship Dr. Wahnschaffe recognizes (p. 101), but it is to be distinctly borne in mind that the Baltic ridge, characterized by the topography which marks the terminal moraines of the United States, is not regarded as a terminal moraine by Dr. Wahnschaffe, or by most of the other north German geologists. The view of professor Penck that the "moraine landscape" is the result of the intimate association of multiple terminal moraines (*Endmoräne*), is more nearly in accord with the American view. But the formation to which the Germans have commonly applied the name of terminal moraine (*Endmoräne*), is regarded by most of them as something very distinct from the Baltic ridge.

If the topography and the constitution of the Baltic ridge were not altogether conclusive in demonstrating its terminal morainic character, according to American classification, additional evidence might be found in the fact that it is bordered on the south by extensive plains of gravel and sand, corresponding to our overwash plains (p. 107). The constitution of these plains corresponds exactly with that of plains in similar positions in our own country, being coarsest near the moraine and becoming finer and finer with increasing distance from it.

The intimate relationship between the "ground moraine landscape" (equal the terminal moraine of the United States) and great

basins is, so far as the United States is concerned, much less general than Dr. Wahnschaffe seems to imply. While it is true that our terminal moraines surround lakes Erie, Michigan and Superior, it is also true that similar moraines frequently stand in no definite relation to well defined basins. The moraine loop which runs down into central Iowa, is not associated with any well-defined basin. The moraine crossing New Jersey and eastern Pennsylvania is altogether independent of any basin, and if such drift ridges are *sometimes* developed independently of basins, they cannot be said to be dependent upon them. The depressions were of course influential in determining the course of ice movement, and so in determining the position and form of the ice's edge, and it is the accumulation of drift made beneath the ice's edge while it was stationary or oscillating, which constitutes, according to American usage, the main part of the terminal moraine.

The conception of American geologists concerning the origin of the terminal moraines ("ground moraine landscape"), is not very different from the view of Dr. Keilhack concerning the origin of the Baltic ridge. It is believed that beneath various parts of the ice's edge, varying amounts of glacial debris accumulated during any given period of time. This in itself, would give rise to a submarginal ridge of unequal hight and width, wherever the edge of the ice remained constant in position for any considerable period. Every minor retreat of the ice may have been accompanied by changes in the details of the form of its edge, and as the margin of the ice changed both in position and in form, new accumulations of drift would be made beneath it, comparable to the first. When the ice re-advanced, never so little, its form might be again changed, and the submarginal accumulations would be made in a new position and in a new form. Thus it is conceived that by repeated retreats and advances within narrow limits, and by repeated alterations in the form of the ice-margin with or without general oscillations, the terminal moraine material was accumulated. The first condition for the development of a terminal moraine therefore, is a stationary ice margin, or a margin which oscillates backward and forward within narrow limits, while the details of its form are continually changing. The extent of these oscillations will be one of the considerations determining the width of the morainic belt. The waters issuing from the edge of the ice, which was always melting, often worked considerable changes upon the ma-

terial deposited by the ice directly, changing both its topography and its constitution. Our terminal moraines are therefore looked upon as accumulations of drift, made beneath the oscillating but nearly constant edge of an ice sheet, more or less modified by glacio-natant waters. The irregularities of topography are regarded as largely the result of unequal accumulation. Horizontal and vertical ice-pressure, as well the vigorous action of ice-water, contributed to the development of the rough terminal morainic topography. This seems to be similar to the view of Dr. Keilhack, except that he would assign to ice pressure, a more important role.

Endmoräne. The formation which has received the name of terminal moraine (*Endmoräne*) in Germany, is a narrow, wall-like ridge, or a series of steep mounds arranged in linear order. Its width for one region is stated to range from 100 to 400 meters. For the same region its average hight is said to be from five to ten meters, though it is occasionally considerably more. The slopes of the ridge, or of the more or less separated hills, have an angle of 30° to 40°. In some regions there are two of these terminal moraines, the one lying several miles within the other. These narrow ridges or series of mounds are made up largely of bowlders. Their constitution and form have given them the name of "bowlder walls" (*Geschiebewälle*). In some cases, the finer material, sand, till, etc., seems to hardly more than occupy the interstices between the bowlders. In other places, sand and till are more important constituents. They sometimes occur within the body of the moraine (*Endmoräne*), interbedded with those portions which consist essentially of bowlders. In some cases, till mantles the "bowlder wall." In other places the terminal moraine (*Endmoräne*) is composed essentially of stratified sand and gravel (p. 113), upon the surface of which only are abundant large bowlders. The course of this "bowlder wall" is somewhat irregular. Generally speaking, it is made up of a series of curves concave toward the direction from which the ice came. Locally, the sharp ridge may grade into a bowlder belt by widening, though it is expressly stated that not all the bowlder belts of north Germany are to be regarded as the equivalents of this terminal moraine. In many regions this terminal moraine, or "bowlder wall," has not so great altitude as the "ground moraine landscape" with which it is closely associated. It courses over the surface of the greater Baltic ridge without much regard to the

topography of the latter, and while it is locally a very conspicuous feature because of its sharp definition and wall-like character, it is quantitatively rather insignificant compared with the great ridge characterized by the "ground moraine landscape." The "ground moraine landscape" topography is generally best developed immediately within this terminal moraine (*Endmoräne*). Outside the same, there are extensive areas of sand and gravel (overwash plains), whose surfaces show little relief.

This diminutive ridge, to which, and to which only, the name terminal moraine is applied by the north German geologists, has no exact counterpart, so far as I know, in the United States. It is explained by supposing that the ice, in its retreat northward remained stationary for a somewhat protracted period in the position which the little ridge now occupies. It is believed to have been constructed out of ground moraine material, from which the finer parts were removed by the waters arising from the melting of the ice. The interlardings of till and stratified sand are explained by supposing oscillations of the ice margin. When the ice overrode the incipient ridge, it is supposed to have left a record of its transgression in a bed of till. When the ice retreated, discovering the growing bowlder wall, this retreat is supposed to be recorded in the beds of stratified sand and gravel which sometimes occur between the coarser materials of the moraine. This terminal moraine (*Endmoräne*) has not been traced throughout its whole extent. It has been traced for considerable distances in the region north of Berlin, and is known at various points east and west of that region. By Dr. Wahnschaffe it is not regarded as marking the limit of ice advance in the last glacial epoch. So far as I am aware, it is not known except in connection with the "ground moraine landscape" topography, though the universality of this relationship is not indicated by our author.

Bowlder Belts. The bowlder belts into which the German terminal moraine sometimes passes are identical in character with the bowlder belts of the United States. The American bowlder belts are believed to be accumulations of bowlders which were carried forward within the body of the ice (considerably above its base), and to have arrived at the surface of the ice before they reached its terminus, because of surface ablation. Transferred thus from an englacial to a superglacial position, they were carried forward upon the surface of the ice to its edge, and there "dumped" upon

the surface of the land.* Had the edge of the ice been constant in position for a long period of time, it is believed that these bowlders would have accumulated in the form of a ridge, or "bowlder wall." That they are so spread out as to constitute a bowlder belt, instead of a "bowlder wall," is thought to be evidence that the margin of the ice was not constant in position.

I was fortunate enough to visit the terminal moraine of the Germans, in the localities which are described as typical, with Drs. Behrendt and Wahnschaffe in the summer of 1888. From the disposition and the form of the ridge under consideration, I was led to believe, that, like our own bowlder belts, it was largely composed of materials which had become superglacial before reaching the margin of the ice, and that the bowlder wall constitutes a good example of a "dump" moraine. Dr. Wahnschaffe urges that the ice sheet could have no superglacial material (p. 107). But it is believed to be possible that material might have been received far up into the body of the ice in the course of its passage over the mountainous lands to the north, and that by surface ablation this englacial material arrived at the upper surface of the ice sometime before it reached the limit of its southward journey. Under these circumstances, such superglacial material might possess many of the characteristics of the ground moraine material. It would have been subjected to much more wear than would the material carried from the outset upon the surface of the ice.

My conception of the correlation of the German terminal moraine (*Endmoräne*), and the "ground moraine landscape" (*Grundmoränenlandschaft*), with the drift formations of the United States is this: The Baltic ridge, characterized by the "ground moraine landscape" or "knob and basin" topography, constitutes a belt or "tangle" of terminal moraines, accumulated beneath the oscillating margin of the ice, when and where it was for a long time nearly stationary. This variety of terminal moraine has been designated "submarginal." The German terminal moraine (*Endmoräne*), resting upon this great submarginal terminal moraine, is a "dump" moraine, accumulated during some minor interval of the time occupied in the accumulation of the greater moraine, when the ice edge was more constant than at other times.

*Chamberlin, Bulletin of the Geological Society of America, Vol. 1, p. 28, 1890.

dumping its surface material along a tolerably definite line. Where the line of dump was inconstant, the line widened to a belt, and here the "dump" moraine became a bowlder belt, which is but a variety of a "dump" moraine. That this "dump" moraine is to be distinguished from the greater belt with which it is associated is evident. The Germans have chosen to apply the name terminal moraine to this wall-like ridge alone. What corresponds to our main terminal (submarginal) moraine, they have designated ground moraine (*Grundmoränenlandschaft*), because it was accumulated beneath the ice. We have chosen to designate both the formation corresponding to their "ground moraine landscape," and the bowlder belts associated, terminal moraines, because they were accumulated at the terminus of the ice. We have separated the two types, as distinct varieties of the general species, terminal moraine.

So far as I am able to ascertain from Dr. Wahnschaffe's volume, he regards the German terminal moraine as accumulated beneath the ice and composed of ground moraine material. It is therefore not easy to see why the term *Endmoräne* is more applicable to it, than to the Baltic ridge, if this latter were fashioned as Dr. Keilhack believes, beneath the margin of the ice. According to Dr. Wahnschaffe's view of its development, the designation terminal moraine would be inappropriate, since he does not believe it to have been made beneath the margin of the ice. Neither the Baltic ridge nor the *Endmoräne* mark the limit of ice advance in Germany in the second Glacial epoch, according to our author. In this respect the phenomena of Germany correspond with those of our own country, where the larger terminal moraines do not generally mark the limit of ice advance, subsequent to the first glacial epoch. My own conclusion concerning the relation between the limit of the later advance of the ice, and the main terminal moraine, was the same as that of Dr. Wahnschaffe.*

Kames(?) Associated with the terminal moraine, there are, in various places, hills and sharp ridges of stratified sand and gravel (*Durchragungszüge*), partially, or sometimes wholly covered with upper till. These elevations are sometimes arranged in linear order, but they do not always sustain this relationship to each other. They may be more or less isolated, or may be so disposed as to form a belt. The layers of the sand and gravel constituting

*Am. Jour. Sci. Vol. xxxv, p. 407, 1888.

the main part of these elevations very generally dip from the center outward. Where the elevations are elongate, the axis from which the layers dip is the same as the axis of the ridges. The surface of these hills and ridges is often marked by an abundance of large bowlders. The mantling till, where it exists, is continuous with the till which constitutes the surface of the "ground moraine landscape" belt, in the immediate neighborhood. The association of these ridges and hills with the terminal moraine (*Endmoräne*), has led Schroeder to the belief that they are closely associated with the latter in origin (p. 110), as well as in position. Their form is ascribed neither to erosion, nor to accumulation. They are regarded as swells or folds pressed up by the ice at its border, during a period when the edge of the ice was nearly constant in position. Because of the peculiar sort of disturbance which the stratification of these elevations has sometimes suffered, Dr. Wahnschaffe's inference seems justified, that lateral thrust by the ice must also have played some part in their origin. Wahnschaffe appears to agree with Schroeder that these hills and ridges were essentially contemporaneous in origin with the terminal moraine (*Endmoräne*). From the description before us, it is not clear that they do not constitute an element of the "ground moraine landscape." It will be seen that Wahnschaffe and Schroeder's view concerning the time and method of origin of these sand and gravel hills, corresponds somewhat closely with Dr. Keilhack's view concerning the time and the method of origin of the elevations and depressions of the region designated "ground moraine landscape." We have already seen that Dr. Wahnschaffe's view of the origin of the "ground moraine landscape," is different. But we believe that Dr. Keilhack's explanation of the "ground moraine landscape" is more nearly correct, and that it is in perfect harmony with Wahnschaffe and Schroeder's view concerning the origin of the sand and gravel hills and ridges associated with the terminal moraine (*Endmoräne*), and with the "ground moraine landscape." Dr. Wahnschaffe indicates the close association of the one class of drift hills with the other, but unfortunately he does not state whether the sand and gravel hills are more commonly associated with the outer or with the inner border of the "ground moraine landscape." He would seem to imply that the association of the German terminal moraine (*Endmoräne*) with the hills here noted, is very close; but since he does

not indicate whether the *Endmoräne* is more commonly found on the outer or on the inner face of the "ground moraine landscape" belt, this relationship between the "*Endmoräne*" and the "*Durchragungszuge*" does not serve to indicate the relation between the latter and the "*Grundmoranenlandschaft*."

We believe that the three sets of phenomena, the "ground moraine landscape" (= our terminal moraine), the German terminal moraine (= a "dump" moraine), and the hills and ridges of gravel and sand (*Durchragungszuge und Käme*), are closely associated in time of origin. We believe that they all represent marginal accumulations, and that together they constitute what is known in America as a belt of terminal moraines. The gravel and sand hills and ridges, with occasional bowlders below the surface, and abundant ones upon it, we regard as kames, and believe that they correspond to the kames so commonly associated with the terminal moraines in America. Locally such kames make up a large part of our terminal moraine accumulations. This correlation is based in part upon Dr. Wahnschaffe's description, and partly upon my own observations. If this interpretation be correct, the terminal moraine (*Endmoräne*) of the Germans, and the accumulations here regarded as kames, should be more commonly associated with the outer face of the belt affected by the "ground moraine landscape" topography than with the inner. But kames are not confined to such positions. Locally they are abundant and well developed on the inner face of the terminal moraine belt, and less commonly at points remote from it. Geinitz has regarded the sand and gravel hills as Asar and kames, (p. 113) but this view does not seem to approve itself to Dr. Wahnschaffe.

There are a few ridges of stratified material not stated to be closely associated with the Baltic ridge, which would appear to be osars. One such is mentioned by Dr. Wahnschaffe at Lubasch in Posen. Others of similar form are excluded from the class osars, apparently on the ground that they are covered by till, while typical osars have not their crests covered by till, though their flanks may be. We do not get the impression from the references to kames and osars (asar) that discriminations between them have been carried to the same extent in Germany as in America. But the distinction between kames and osars has only recently come to be generally recognized here.

The discussion concerning the position of the "old" valleys, and

their relations to the courses of the present streams, is an interesting study in river drainage. The valleys of the "old" streams have been filled to considerable depths with sand, emanating from the glacier formations. In some places, and for considerable stretches, these "old" valleys are now dry. In other places they are occupied by inconsiderable streams. It would be a matter of great interest to know whether the "old" valleys are pre-glacial, or whether they are interglacial in origin. We infer that their sand filling is regarded as last glacial (p. 128). If it could be shown that the excavation of the "old" valleys was interglacial, or that any considerable part of their excavation was interglacial, such demonstration would be a convincing proof of a long interglacial epoch.

Loess. On the southern border of the north German lowland there is a narrow belt of country covered with loess, although the loess is not confined to that portion of Germany which is properly designated "lowland." It reaches to the southward so far as to cover the lower portions of the southern upland. The loess is well developed in the northern part of Saxony and in the vicinity of Halle and Magdeburg. The topography of the loess-covered country is gently undulatory. A large number of the German geologists who have studied the loess appear to have adopted the æolian hypothesis. Dr. Wahnschaffe, on the other hand, believes the loess to have been deposited by water, and by water which arose chiefly from the melting of the ice in the *last glacial epoch.* He conceives the water which deposited the loess to have accumulated in a number of more or less connected basins, lying between the ice on the north, and the highlands beyond the ice on the south. The waters thus confined between ice and upland had an outlet, so it is believed, toward the northwest: but it is held that the movement of the water was so gentle that it was able to carry away only the finest clayey material, while the materials of silt-grade of coarseness were deposited in the area covered by the water, and constitute the loess. The northward drainage from the highlands on the south, and the southward drainage from the ice on the north, both contributed to the formation. The altitude of the loess is stated to be about 282 feet in Saxony, while it rises to the hight of 600 feet in the Harz mountains.

The chief reasons quoted from its advocates in support of the æolian hypothesis, are the presence of fossils of land animals,

Dr. Wahnschaffe does not give specifically the reasons for his belief in the aqueous origin of the loess, though he devotes some space to a consideration to the arguments of those who believe that it was deposited by the wind. We think that Dr. Wahnschaffe's arguments against the æolian hypothesis have much force. After a brief examination of the loess in several points in the vicinity of Magdeburg, in company with Dr. Wahnschaffe, I was convinced that his view concerning the origin of the loess was the right one for that region. I have no data for an opinion concerning the time of the origin of the German loess. If it belong to the time of the last glaciation, it does not correspond in point of time of origin with the great body of the loess in the United States; but that is no reason for believing that Dr. Wahnschaffe's interpretation is not right. It is believed that the loess in the United States originated at different times. I am inclined to think that some of it may have originated in connection with the last glacial epoch, and I know no reason why that may not have been the time of the chief accumulation of the loess in Germany.

The Lakes. The relationship between the distribution of lakes and the extension of the ice sheet is the same in Germany as in the United States. The lakes are chiefly confined to the area which suffered glaciation, and to the area which suffered glaciation the second time. But it is to be observed that they do not have a general distribution over the whole of the area which the last ice sheet invaded, as Dr. Wahnschaffe would define that area. Southwest of the Elbe, for instance, lakes are almost wholly wanting. This fact is in itself an evidence, though alone not a conclusive evidence, that this region was not glaciated in the last epoch. It is to be remembered that not all German glacialists are agreed that this region (the *Luneburger Heide*) was covered by ice in the last ice epoch. The absence of lakes supports the negative. Lakes are most abundant along the Baltic ridge, where the "ground moraine landscape" is best developed, just as they are most abundant in our country, along the courses of the terminal moraine. They are not infrequent north of this ridge, and in some parts of Germany they cannot be said to be rare south of it.

The question as to the origin of the lakes which lie within the drift-covered territory of Germany, is one concerning which there has been much discussion and much difference of opinion. Inter-

esting as the history of opinion on this point is, we shall content ourselves at this time with mentioning only Dr. Wahnschaffe's views. Be it remarked, however, that it has always seemed to the writer that much of the discussion concerning the origin of the German lakes, masked a broader question, which embraced the narrower one discussed. Enclosed depressions are one of the conspicuous features of the "ground moraine landscape." Many of these depressions do not become lakes because of pervious bottoms. But the dry "kettles" are just as significant as those filled with water. The depressions are associated with hills and ridges which constitute the second conspicuous feature of our terminal morainic topography. The association of these two features is such as to make it necessary to suppose that the explanation of the one must take account of the other; that the processes which called forth the one, were responsible also for the other. The question at issue, therefore, is not the origin of the *lake basins*, but the origin of the *hills and basins* (whether occupied by water or not), that is, the origin of the "ground moraine landscape" (our terminal moraine) topography. This is not so much a criticism of Dr. Wahnschaffe's discussion as a comment upon some of the discussions which have preceded this volume, and which are cited in it.

Dr. Wahnschaffe recognizes several classes of lakes. One class is designated the "ground moraine lakes" (*Grundmoränenseen*). It is to this class of lakes to which the foregoing comment is relevant, and Dr. Wahnschaffe does not regard their origin as a question distinct from the origin of the topography of the Baltic. He would therefore make the origin of these basins contemporaneous with the origin of the topography with which they are associated. A second class of lakes are associated with the *Endmoräne*, and occupy depressions, of which this ridge constitutes one of the bounding walls. They are basins formed by morainic dams. A third class of lake basins are attributed to the eroding action of the waters arising from the melting of the ice, either as they plunged through crevasses, excavating small circular hollows below, or as they flowed through their sub-glacial or extra-glacial courses. Many of the lakes which are connected with each other as beads on a string, are referred to such an origin. Still other lakes, few in number and small in size, may be the result of underground solution.

Post Glacial Changes. Not the least valuable chapter of the book is the discussion of the surface changes which the German territory has undergone in postglacial time. Certain criteria, which have at one time and another been used as evidence of change of level, are discussed and their errors clearly pointed out. Evidence of great changes of level in post-glacial time is not found in the coast region. The topographic distribution of the loess in southern Germany, so far as its altitude in different regions is given, would raise the question whether there may not have been considerable surface warping in that region.

Although I have dissented from some of Dr. Wahnschaffe's conclusions, some of these differences are more apparent than real, because of the diverse use of terms. Others are more fundamental. To accomplish the purpose for which this paper is written, it has been necessary to emphasize the points wherein American and German views differ most widely, passing over in silence many of the more numerous points of agreement. But the book is throughout suggestive, and on the whole a most satisfactory compendium of present knowledge concerning the glacial formations of Germany.

GAS WELLS NEAR LETTS, IOWA.

By Prof. F. M. Witter, Muscatine, Iowa.

In the early part of December, 1890, Mr. T. L. Estle, living in Section 3, Township 75 N. Range 4 W. 5th Principal Meridian, sunk a well on his farm for water. In drift at a depth of about 100 feet he struck gas which burned readily, but in two or three days the gas ceased to flow. Between 40 and 80 rods west of this place about the same time Mr. R. M. Lee bored for water. At about 100 feet he failed to get water and stopped boring.

In the evening he commenced to pull out his casing, and succeeded in raising it perhaps 8 or 10 feet. During the night a great roaring was heard, and on approaching the well with a lantern the gas took fire and a great flame shot several feet into the air with a frightful noise. In a few days the flame was extinguished, and the gas piped into Mr. Lee's house, a few rods away, where for over a year it has furnished him light and fuel.

This well now furnishes Messrs. R. M. Lee, T. J. Estle, J. E. Lee and Robert Lee with all their fuel and light. Mr. Robt. Lee is a little over one mile from the well.

It is carried in common gas pipe laid on the top of the ground. The pipe is 2 in., $1\frac{1}{2}$ in., and the last half mile 1 in. in diameter.

This well supplies 12 fires and 16 lights.

No estimate has been made as to how many more it might supply, but the number would certainly be quite large.

Mr. J. E. Lee stated that the opening admitting the gas from the casing of the well to the main was considerably less than the size of an ordinary lead pencil, and that it flowed a half mile in the main in 14 seconds. How this rate was satisfactorily ascertained we did not learn.

The same gentleman said the pressure at first was about $5\frac{1}{2}$ pounds, which has steadily risen till it is now 12 pounds. From a large stream issuing in our faces we could detect a faint odor resembling ether or chloroform. It gives a fine steady light and most intense heat in the stoves and artistic grates. It seems in all respects to be equal to or superior to the best artificial illuminating gas. The gas is used just as it is when it issues from the well.

Within a circle of about three miles in diameter in the townships named above, from at least seven wells sunk for water, gas issued. The depth to the gas ranges from about 90 ft. to 125 ft. At a depth from 6 to 25 feet below the gas a good, constant supply of water is obtained. It seems to be very easy to shut off the gas by the rapid sinking of the casing in a sort of blue clay with some sand, in which the gas is thought to be stored. The clay seems to form a tube as the drill and casing descend, and this prevents the gas from getting into the well, unless it is given a little time at the right place. The country for miles around is full of wells, which are all believed to be sunk to the water below the gas, without discovering the gas for reasons given above.

I made the following tests on the water from below the gas. With potassium ferrocyanide I observed no reaction. On evaporating perhaps 50 cc. a considerable amount of solid matter was obtained. This was of a somewhat yellowish brown color, and effervesced readily with hydric chloride. This solution when tested with potassium ferrocyanide gives a deep blue. I was led

to believe from these tests that the water contained a carbonate and some compound containing iron in solution.

At a depth of 18 or 20 feet, water has generally been found in this locality, but the supply is variable. Mr. Robt. Lee has a well which he dug several years ago, the water of which was excellent and in good quantity. This well is about 18 feet deep and carefully walled. Last summer he bored for water about 100 feet from this well. At a depth of a little more than 100 feet he found a little gas issuing at irregular intervals. Immediately after the appearance of the gas the water in the shallow well became muddy and unfit for use, and has remained so, though the water seems to be much worse at times, which are irregular.

It seems to me that the gas rises outside of the casing to the porous bed holding the water of the shallow well, and passes through this to the well and injures the water.

The country in which these wells are located is comparatively level. Indications are at hand everywhere of a boggy or peaty nature. There are but few low hills and no ravines of any note. The soil is a rich black loam, and the whole region is said to be destitute of the boulders so common in many parts of Iowa, and especially of Muscatine county. Mr. J. E. Lee stated that wells in this region had been sunk 280 feet, and no rock had been reached.

The well in Muscatine county from which gas is used is on the farm of Mr. Jno. Idle, in Section 35, Township 76, Range 4 W.

The farmers in the neighborhood of these gas wells are about to complete an arrangement to put down a well 2,000 to 2,500 feet deep. This is to determine whether there is oil below the gas.

It is my own impression that the gas comes from considerable beds of vegetable matter buried in this unusually heavy drift deposit in this region. The area, it seems to me, which is thus underlaid, is 6 or 8 miles long, and perhaps 3 or 4 miles wide.

I should expect to find the rocks here directly below the drift to be of the Devonian age.

This locality is on the east side of the Cedar river. The nearest well to the Cedar is about two miles distant. No gas has yet been found on the west of the Cedar.

CLIMATIC CHANGES INDICATED BY THE GLACIERS OF NORTH AMERICA.

By ISRAEL C. RUSSELL, Washington, D. C.

Prof. Dufour has shown that the existing glaciers of Europe and Asia are retreating.* This is proof of a marked climatic change over a great area, within the last one or two decades, and renders it important to know if evidence of a similar change is furnished by the glaciers of other regions. Should it be found that glaciers on other continents are also retreating, it would not only be an interesting contribution to physical geography, but have an important bearing on the study of the causes of the Glacial Epoch.

The data presented in this paper in reference to recent changes in the glaciers of North America, have been assembled in response to a letter addressed to the Director of the U. S. Geological Survey by Prof. Dufour, and is here published with the hope that it may lead to the accumulation of additional data in the same connection.

Distribution of Existing Glaciers in North America.

Glaciers may be arranged, provisionally at least, in three classes, viz:—alpine, piedmont and continental. It is also convenient to designate those which enter the ocean and break off in bergs, as tide water glaciers. Examples of each of these types occur in North America.

The glaciers of North America are confined to the Cordilleran system and to the Greenland region. Small ice bodies are known to exist on the higher volcanic peaks in Mexico, but of these we have only indefinite information. Their southern limit in the United States is in the High Sierra of California, in about latitude 37° N. The ice bodies in that region are small but have the essential features of the largest alpine glaciers. They are confined to cirques near the mountain summits and do not descend below a horizon 12,000 to 13,000 feet above the sea. In northern California, Oregon, and Washington, glaciers become more numerous, of greater extent, and extend to lower horizons than in the High Sierra. They occur about the summits of Mt. Shasta, Mt. Rainier, Mt. Baker, and several other peaks in the Cascade mountains, which have an altitude exceeding 10,000 or 11,000 feet. In the Rocky mountains they begin at the south, with snow bodies in Colorado, which by some

*Bull. Soc. Vaud Sc. Nat., Vol. XVII, 1881, pp. 422-425.

are considered as true glaciers, and increase in number and extent towards the north. In the Cordillera system in Canada, glaciers are numerous, but have been explored to only a limited extent. Those best known are in the Selkirk mountains and on the Stikine river. Farther north in the same great mountain belt, many glaciers are known to exist, and in Alaska they reach their greatest development. As one follows the glacial belt northward the lower limit of perpetual snow descends lower and lower, until finally at the base of Mt. St. Elias its elevation is only about 2,500 feet above the sea. The glaciers extend below the snow line and reach sea level near the mouth of the Stikine river in about latitude 57°. From there northwestward to Cook's inlet there are hundreds, if not thousands, of magnificent ice streams which descend nearly to the ocean level, and scores which enter the ocean and breaking off form bergs. Local glaciers clustering about high peaks, occur on the Alaskan peninsula and the Aleutian islands. This great glacier belt is approximately 3,000 miles long. The most thoroughly snow and ice covered portion is in the region about Mt. St. Elias, where not less than 30,000 square miles of exceedingly mountainous country is completely buried beneath a vast névé field which is drained by glaciers of the alpine type flowing both north and south. Those flowing south are the more important.. On gaining the flat lands between the base of the mountains and the sea, they expand and form Piedmont glaciers. Of these, the Malaspina glacier, having an area of about 1,500 square miles, is the best known example. An interesting fact in connection with the distribution of glaciers on the west coast of North America is that their northern limit is less than one hundred miles north of Mt. St. Elias. Mountains in central and northern Alaska having an elevation of 4,000 or 5,000 feet are without snow during the summer and no glaciers exist upon them. As is now known this region was not glaciated during the Glacial Epoch.

On the east side of North America existing glaciers are confined to Greenland and to neighboring islands. The ice sheet covering Greenland is of the continental type and, as is well known, is the largest existing ice body in the northern hemisphere. The glaciers on the islands west of Greenland are of the alpine type, and many of them are known to be of great size, but their exploration is far from complete.

Are the Glaciers of North America Advancing or Retreating?

The glaciers of this continent have been known for so short a time that only small portions of their histories have been read. Their study is comprised almost entirely within the past decade and has been carried on in such a desultory way that for the most part only qualitative evidence as to their advance or retreat is available.

Character of the Evidence: Evidence of the advance or retreat of the ends of alpine glaciers, or of the borders of piedmont and continental glaciers, may be obtained in various ways. Glaciers which are advancing sometimes plow into the debris in front of them and force it up in concentric ridges, usually with the formation of cracks in the soil. The surfaces of the ridges formed in this way are frequently covered with vegetation, which in addition to their forms and the character of the material of which they are composed, serves to distinguish them from terminal moraines. When a glacier advances into a forest, the trees are broken off and piled in confused heaps about the margin of the ice. The upper surface of a glacier is known to flow faster than the ice below, and an advance is probably accomplished by the upper surface flowing over and burying the ice which rests on the ground. For this reason, advancing glaciers usually present bold scarps at their extremities, and, in general, are not covered with a broad sheet of debris.

In retreating glaciers the layers of new snow deposited on the névé fields and changing to ice as they flow downward, are melted before reaching the margins of the ice streams, and the slow moving ice at the bottom is thus left exposed and melts away. The retreat is accomplished not by a contraction in the volume of the ice-body, but by the melting of its distal extremity. The ice which is not covered by fresh layers melts at the surface, and the englacial debris which it contains is concentrated in a general sheet forming fringing moraines. When a sheet of debris of this character is extensive and covers the lower portion of a glacier from side to side, it indicates that the ice beneath is practically stationary and consequently is melting and retreating. The ends of retreating glaciers frequently have a gentle surface slope, and in many instances are so completely concealed by debris that the actual terminus of the ice cannot be distinguished. When the moraines are heavy, however, and especially when they are clothed

with vegetation, the melting of the ice beneath is greatly retarded, and in some observed instances the glaciers thus protected terminate in bold scarps.

When a glacier retreats more rapidly than soil can form on the abandoned area, so as to admit of the growth of plants, a desolate tract is left about its end, on which concentric lines of stones and boulders may indicate halts in the retreat. Barren areas of this nature, when the lack of vegetation is not due to the action of water from the ice, are good evidence of recent glacial recession. When glaciers which flow through a valley having steep sides, become stagnant, a general lowering of the surface, decreasing up stream, takes place, which leaves the bordering slopes bare of vegetation. The action of rain and rills on such surfaces may indicate to some extent the length of time they have been exposed. The presence of fine glacial debris on slopes from which it would be easily washed by rain, may also furnish evidence in the same connection. Retreating glaciers sometime leave detached masses of ice which are melted in the course of a few years and hence indicate rapid changes. The amount of subaerial erosion on glaciated areas may also serve to indicate the length of time they have been exposed.

These various classes of evidence usually enable one to determine definitely whether a glacier has recently advanced or retreated, and may sometimes afford a clue to the rate of these changes. In the study of the glaciers of America we have at present no definite quantitative measurements, and must rely on such phenomena as have been indicated.

California: Some of the small glaciers in the High Sierra were visited by me in 1883 and 1884. I found that they were certainly not advancing, and from the occurrence of barren area about their extremities judged that they were slowly receding, but could not obtain evidence as to the rate of the recession.

Observations by J. S. Diller, of the U. S. Geological Survey, on Mt. Shasta, indicate that the glaciers in northern California, like those farther south, are retreating. Evidence of this is furnished by barren areas about the ends of several of the glaciers and by a conspicuous lateral moraine on the side of the Whitney glacier, which in 1887 was about twenty-five feet above the level of the adjacent ice.

Oregon and Washington: The glaciers on the Cascade mount-

ains have been visited by a number of persons, but I have been unable to obtain satisfactory evidence of advance or recession. An inspection of photographs of the glacier on Mt. Rainer indicates that they end in areas bare of vegetation, which presumably were recently occupied by ice.

British Columbia: The glaciers of British Columbia, although numerous and important, are but imperfectly known, and only a few observations on recent changes have been made. Many of these glaciers, however, have been seen by Dr. G. M. Dawson, who informs me that in no instance are there evidences that they have recently advanced, and considers it is safe to assume that they are either stationary or slowly receding.

R. G. McConnel, of the Canadian Geological Survey, has kindly informed me that the glaciers, both on the Stikine river and in the Rocky mountains, have shrunken back from fresh looking moraines, and that the intervals between the ice and the moraines, in all instances examined by him, were destitute of trees and contained but little vegetation of any kind. In his opinion a marked retreat has occurred within the last century or two, but whether it has been in progress during the past one or two decades cannot be decided from the evidence in hand. Observations made by Macoun and Ingersoll confirm this conclusion.*

I visited the Illecellewaet glacier at Glacier station, on the Canadian Pacific Railroad, in the spring of 1891, and found a barren area, intervening between the ice and the encircling forest, several hundred yards in breadth, which had evidently been but recently abandoned by the glacier. A small moraine on the western side of the glacier also suggested a recent shrinking of the ice. The evidence of a recent retreat of this glacier has also been noted by W. S. Green.†

An absence of vegetation about the extremity of one of the glaciers on Stikine river was noted by Blake,‡ and may probably be taken as an indication of a recent retreat of the ice. A legend current among the Stikine Indians indicates that two glaciers on opposite sides of the stream were formerly united and that the river then flowed through a tunnel beneath the ice.

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*Mountaineering in British Columbia, by Ernest Ingersoll, Bull. Am. Geog. Soc., Vol. XVIII, 1886, p. 18.

†Among the Selkirk glaciers, London, 1890, p. 69.

‡American Jour. Sci., Vol. XLIV, 1867, pp. 96-101.

Alaska: The evidence that a general retreat of the glaciers of Alaska is still in progress is abundant, and in a few instances is of quantitative value.

Lynn Canal: About this magnificent inlet there are many ice streams of the alpine type, which descend nearly to sea level, but none of them are now actually tide water glaciers. About the ends of many of them there are dense forests of spruce trees which must have been growing for at least one hundred and fifty years, but between the forests and the present terminus of the ice there is in several instances a barren area covered with morainal deposits and bearing every indication of having but recently been abandoned by the glaciers.* These conditions are especially noticeable at the extremity of the Davidson glacier, situated on the western side of the inlet near its head, which expands into a broad ice foot on leaving the wild gorge through which it flows. Between the present terminus of the ice and the encircling forest there is a barren tract half a mile broad, which has been left by a retreat of the ice so recently that vegetation has not been able to take root upon it. A decided retreat of the ice has here recently occurred, and to all appearances is still in progress, but no observations of its rate have been made.

Conditions similar to those seen at Davidson glacier were observed in connection with several other ice streams in the same region. In Taku inlet, the Norris glacier comes down to sea level, but is separated from the water by broad mud flats. There is no indication that this glacier has recently advanced and an accumulation of debris over its surface indicates that it is melting away. The Taku glacier near at hand, is of the tidewater type and evidence of recent changes are wanting.

Glacier Bay: The evidence of recent changes in Muir Glacier have been presented by Wright,† who has shown that it has quite recently been both more extensive and of less size that at present. Additional evidence of these changes have been supplied by Reid, ‡ who concludes that Muir Glacier and other ice streams now discharging into Glacier bay, were form-

*Bull. Geol. Soc. Am., Vol. I, 1890, p. 152.

†The Ice Age in North America, by G. Frederick Wright, New York, 1889, pp. 51-57.

‡Studies of the Muir Glacier, by H. F. Reid, National Geographic Mag., Vol. IV, 1891, pp.

erly much more extensive than at present, and at the time of the Vancouver's expedition in 1794, probably occupied the whole of the bay to a point some distance below Willoughby island. The retreat during one hundred years is thought to be in the neighborhood of fourteen miles. This conclusion, however, rests on certain passages in the narrative of Vancouver's voyage* which may possibly refer to floating ice, and not to actual glaciers, and therefore not have the quantitative value indicated above. But under any plausible rendering of Vancouver's account, it does not seem possible to escape the conclusion that the ice in Glacier bay was far more abundant at the time of his visit than in recent years.

Observations made by Wright and Reid in 1886 and 1890, respectively, show that Muir glacier has retreated during this interval more than 1,000 yards. This observed rate of recession would, if continuous for one hundred years, produce a retreat of approximately fifteen miles, and affords ground for believing that the great retreat supposed to have occurred since Vancouver's visit is approximately correct.

John Muir has kindly contributed the following note concerning the retreat of the glaciers of southeastern Alaska, which confirms the evidence already presented:

"All the glaciers that have come under my observation in southeastern Alaska have retreated and shallowed since first I became acquainted with them in 1879 and 1880. Those in which the declivity of the channels is least, have of course receded the most. During the ten years between 1880 and 1890, Muir glacier has receded about one mile, at its mouth in Muir inlet."

St. Elias Region: Much space could be occupied in recording observations which indicate a general recession of the glaciers about Yakutat and Disenchantment bays and along the adjacent ocean shore, but a brief summary of this evidence is all that seems necessary at this time.

The lower portions of a large number of glaciers in this region are completely covered by continuous sheets of debris which has been concentrated at the surface through the melting of the ice. This debris is not being carried forward and deposited in terminal moraines, but is distributed over the surface of the ice in a thin

*Voyage of Discovery around the World, by Vancouver, Vol. v, pp. 420-423. Quoted by Wright in Ice Age of North America, pp. 55-57.

sheet and marks the stagnant condition of the glacier on which it rests. In several instances, especially on the outer border of the Malaspina glacier, the moraines resting on the ice are clothed with vegetation, which over many square miles has the character of a forest, composed principally of spruce trees, some of which are three feet in diameter. Within the forest covered border and forming a belt concentric with it, there is a barren tract covered with stones and boulders. The forests growing on the glacier and also thousands of lakelets, both in the outer border of the barren moraine and in the adjacent forest-covered moraine, indicate conclusively that the ice-sheet is stagnant and consequently wasting away. On the coast bordering the Malaspina glacier on the south, there were formerly two projections called point Rio and cape Sitkagi which were noted by the explorers one hundred years ago. In traversing this coast in 1891, I found that no capes exist at the localities referred to. At the site of cape Sitkagi there is evidence that the sea has recently invaded the glacial boundary. On the sides of many of the alpine glaciers in the St. Elias region there are steep slopes bare of vegetation although well below the upper limit of tree-growth of adjacent areas, which indicate that the ice streams have recently shrunken within their beds. My conclusions after two visits to the glaciers in the St. Elias region is that without exception they are rapidly retreating.

Near point Manby there is a locality where the Malaspina glacier has recently advanced about 1,500 feet into a dense spruce forest, cutting off the trees and sweeping them into confused heaps. After advancing, the ice retreated, leaving a typical moraine surface filled with lakelets. This is the only instance of a recent advance that has come under my notice.

The head of Yakutat bay was visited by Malaspina in 1791, and again by captain Puget in 1794. Each of these explorers found the inlet blocked by a wall of ice from shore to shore. No other observations in this connection were made until my visit in the summer of 1890.* From what may now be observed it is evident that the Dalton and Hubbard glaciers, which come down to the water at the head of the inlet and break off in bergs, must have extended some five or six miles beyond their present

* Map indicating the position of the ice in 1791 is shown on plate 7 and its extent in 1890, on plate 8, of my report on an expedition to Mt. St. Elias, in Nat. Geog. Mag., Vol. III. This is only a sketch map, and cannot be relied upon for measurement of distances.

position at the time of Malaspina's and Puget's visits, and were then united so as to completely block the entrance to Disenchantment bay, which is a continuation of Yakutat bay. These observations show conclusively that the glaciers mentioned have retreated five or six miles within the past one hundred years. The small recession that has here taken place, in comparison with the changes reported in Glacier bay, during the same time, is probably due to the fact that the névé from which Muir glacier flows, is much lower than the snow fields drained by the Hubbard and Dalton glaciers, and presumably more sensitive to climatic changes.

North Side of the St. Elias Mountains: Dr. C. Willard Hayes, of the U. S. Geological Survey, in crossing from Selkirk house on the Yukon river to Copper river, in 1891, passed for a portion of the way along the northern border of the great system of mountains which culminate in Mt. St. Elias, and discovered several large glaciers of the alpine type flowing northward from the névé field north of Mt. St. Elias, and also other glaciers draining névé fields about Mt. Wrangell and flowing southward. Respecting the evidence of recent changes in these glaciers, Dr. Hayes has kindly supplied the following notes:

Two large glaciers and many small ones were seen flowing from the St. Elias mountains northward into the White river basin. Another flows from the southeast into the pass and drains into both the White and Copper river basins. About the head of the Nizzenah are four large and many small glaciers. Flowing into Copper river from the coast range are four or five glaciers, one of them—Miles glacier—being larger than any seen further in the interior. Observations were thus made on twelve glaciers, and with one exception to be described later, all show a more or less rapid recession. The evidence of this recession in most cases is the accumulated moraine covering the terminal edge of the glacier; or where there is not sufficient englacial drift to accumulate and form a protective mantle, the stagnant ice melting to a feather edge. The White river lobe of Russell glaciers is of the moraine covered type, while the Nizzenah lobe has the feather edge. On the Klutlan and Russell glaciers the outer portion of the moraine covered ice supports a dense vegetation, which becomes gradually more scanty and disappears about half a mile from the edge of the ice. The recession of the smaller glaciers along the Nizzenah appears to have been more rapid than the advance of the vegetation so that between it and the ice is a belt of bare moraine.

Miles glacier terminates in an ice cliff fronting upon Copper river and the river has as yet cut only part way through the dam formed by

the northern lateral moraine. This moraine must, until very recently, have been backed up by the glacier itself, though the front of the latter has now retreated two miles to the eastward.

While the fact of recession is manifest, the rate is more difficult to determine. In one case, however, it is possible to connect the amount of recession with an important episode in the history of the region, namely, the eruption of a wide spread deposit of volcanic ash which extends from near the head of the Pelly westward to Scolai pass. With regard to the age of this deposit Dr. Dawson says:* "While the eruption must have happened at least several hundred years ago, it can scarcely be supposed to have taken place more than a thousand years before the present time."

For a distance of about three miles in front of the Klutlan glacier there is a deposit of moraine material perhaps 200 feet thick, composed of volcanic ash and angular rock fragments. This evidently fixes the position of the glacial front at the time of the volcanic eruption, and the amount of recession since that event. It is interesting to note that on the present glacier surface the volcanic ash is found only a short distance from the end, showing that since the eruption, while the front of the glacier has receded about three miles, nearly the whole mass of the glacier has been renewed by fresh addition from its source.

The single exceptional case already referred to, is the Frederika glacier, which seems to be advancing its front instead of retreating. It has its source in the high mountains forming the eastern members of the Wrangell group, and flows south in a lateral valley, joining the valley of the Nizzenah at right angles. The front of the glacier is parallel with the river and about three-fourths of a mile from it, the intervening space being a gravel plain. The glacier terminates in a nearly vertical ice cliff about 250 feet high. It is slightly convex, and stretches entirely across the valley about a mile in length. The surface of the glacier is free from moraines but is extremely rough and broken, unlike the ordinary surface of stagnant ice at the end of a retreating glacier. At the foot of the cliff is a small accumulation of gravel and fragments of ice, probably pushed along by the advancing mass.†

An explanation of this anomalous case is suggested. Ten miles to the westward of the Frederika another much larger glacier flows into the valley of the Nizzenah. This is formed by the union of three separate streams, and of these the eastern appears to be retreating much more rapidly than either of the others. But this eastern branch probably has its source in the same basin as the Frederika glacier, and it seems not impossible that by some means the drainage has been diverted from the western to the eastern outlet, thus causing the rapid retreat in the former glacier and advance in the latter.

*Report on Yukon District, p. 45 B.

†This is the only instance of an advancing glacier known on the west coast of North America. I. C. R.

Greenland: Regarding recent changes in the ice sheet of Greenland there is but scanty evidence, and such observations as have been made on the advance and retreat of the margin of the ice are conflicting. Holts found in 1880, between latitude 61 and 65° 30′, on the west coast, according to Lindahl,* that "the border of the ice appeared to have retreated quite recently in many places; in others it had decidedly advanced." Nansen† remarks in this connection that we cannot even conjecture what the present conditions are, and thinks that the observations show that there is no strong tendency either towards advance or retreat. Warren Upham,‡ who has recently reviewed the literature relating to the Greenland ice sheet, informs me that in his judgment the ice is now slightly increasing in thickness and generally in extent. This conclusion rests largely on the general absence of debris on the borders of the ice sheet. His studies have also led him to the conclusion that Greenland, in common with other portions of the northeast border of this continent, is now having an appreciable increase in cold.

The observations of those who have traversed the inland ice seems to indicate that nearly its entire surface is in the condition of a névé, and suggest that growth and not retreat must be in progress. The absence of debris on the borders of the ice sheet referred to by Upham, is important in this connection, and seems to indicate that no great waste of ice occurs before it is discharged into the sea. So far as one may judge from the observations of others, it seems as if the evidence available points to an increase of the ice sheet, as supposed by Upham, but I do not give much weight to this conclusion. Dufour, however, in a paper cited in the beginning of this essay, is inclined to the opposite conclusion. He states that in 1880 he made a communication on the retreat of the glaciers of Europe and Asia before a scientific congress at Reims, and that during the discussion which followed one of the persons present, who had been in Greenland several times, mentioned that he "had noticed that the glaciers of that land had also

*Am. Nat., Vol. 22, 1888, p. 593.

†First Crossing of Greenland, Vol. II, p. 491.

‡The conclusions of Mr. Upham are also contained in the following papers:—"On the cause of the cold of the Glacial Epoch," Am. Geol., Vol. VI, 1890, p. 336; and "The ice sheet of Greenland," Am. Geol., Vol. VIII, 1891, p. 150; "Criteria of englacial and subglacial drift," Am. Geol., Vol. VIII, 1891, p. 385.

retreated considerably." It is known that the glaciers of Greenland were much more extensive during a former epoch than at present, and left records at an elevation of 3,000 feet above the present ice surface.* It may be suggested that the observations referred to by Dufour possibly relate to these ancient records.

Weight of the Evidence: The observations summarized in this paper in reference to the Cordillera region, although unsatisfactory in many ways, indicate with a single exception which seems to have a special explanation, that the ice bodies in that region are retreating. This conclusion not only rests on direct observations of several individuals, but is sustained by negative evidence as well. An advance of a glacier, especially in a forested country, is apt to be strongly marked, and would attract the attention of even a casual observer, but in no instance, with the exception reported by Dr. Hayes, and the slight extension on the border of the Malaspina glacier already mentioned, has a recent advance of the glaciers been reported.

The fact that the glaciers at the head of Yakutat bay have retreated several miles within the past one hundred years, as well as the still greater recession of the glaciers of Glacier bay during the same period, indicates the present general recession of the glaciers of the Pacific coast has probably been in progress for more than a century. During this time there must have been many minor oscillations which our imperfect observations do not detect but the fact that the general movement has been backward is well sustained.

The shrinking of the glaciers of the west coast of North America, together with the conclusions reached by Prof. Dufour to the effect that the glaciers of both Europe and Asia are receding, indicate that the Greenland ice sheet is the only one in the Northern Hemisphere which is not now diminishing.

Climatic changes: The advance and retreat of glaciers depends on climatic change. Glaciers, like enclosed lakes, record the result of the sum total of climatic changes which favor the retention of moisture on the land. In general it is safe to assume that increased precipitation will favor their growth and a rise of temperature lead to their retreat. A general decrease in the glaciers of the Pacific coast suggests that other evidence of a secular climatic change should be found in the same region. To

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*Am. Jour. Sci. 3rd ser., Vol. 24, pp. 100-101.

discover if there is any connection between the retreat of glaciers and recorded observations on climatic changes, it would appear that an inspection of the records of mean annual temperature and mean annual rainfall, without discussing the causes of these changes, would be sufficient. Difficulty in the way of making this comparison arises, however, from the fact that in the glacial records we have only the general result of a long series of changes, all minor features of which are lost; while in the weather records sufficient time has not been covered by the observations to show secular changes a century or more in extent, which would be necessary to reach a satisfactory conclusion. The weather records on the Pacific coast did not begin until 1849, and were not made at a sufficient number of stations to furnish a basis for determining general climatic changes until a number of years later. This lack of observations render it impossible to make the comparison desired. The same proves to be true also on attempting to correlate the retreat of the glaciers with the weather records of the entire North American continent. The only conclusion to be reached in this connection seems to be that the data relating to both the fluctuations of glaciers and to climatic changes are inadequate for satisfactory comparison.

Curves showing secular changes in temperature and rainfall of the world for more than one hundred years, derived from all available weather records, have been published by Dr. Bruckner,* of the University of Berne. The observations of temperature embrace the period between 1730 and 1885 and show a gradual rise during the latter part of this interval. The curve indicating rainfall includes the period between 1775 and 1885, and shows a gradual decrease towards the end of this period. These results seem in harmony with the decrease of the glaciers of Europe and Asia and of the west coast of North America, but how accurately the curves indicate actual changes in the elements of climate referred to it is impossible to say. The general rise in the temperature curve, the gradual fall in the curve representing precipitation, towards the end of the periods of observation are probably influenced by the varying character of the observations during different portions of the period. The correspondence between the general retreat of the glaciers in the northern hemisphere and the changes in the records of temperature and rainfall referred to

*Penk's Geog. Ablandlunger, Vol. IV, 1890, p. 329.

above may be valid, but it seems to me for various reasons, that but little weight should attach to it.

The comparison of the retreat of glaciers on the west coast with the rise and fall of the lakes of that region, more especially of the enclosed lakes, would be instructive, but here again, as in the case of the weather records, no records covering a sufficient length of time are available. Observations on the rise and fall of Great Salt lake show many fluctuations, but no general decrease which is comparable with the retreat of the Cordilleran glaciers.*

The geological records of lakes Bonneville and Lahontan show two maxima separated by a minimum, which latter indicates a period of desiccation, and followed by a second minimum which extends to the present day. The retreat of the glaciers on the west coast seems in harmony with this record. The desiccation of the lakes referred to has accompanied the retreat of the glaciers on neighboring mountains, but has been more rapid. It is believed that the lakes of the Great Basin had their last maximum at the time the Sierra Nevada was covered with glaciers. A general decrease in the glaciers appears to have accompanied the desiccation of the lakes and is still in progress.

The retreat of the glaciers on the Pacific coast, as shown by rough quantitative determinations at Yakutat and Glacier bays, has been in progress for not less than one hundred years. The character of the forests about the extremities of the glaciers of Lynn canal, show that the ice streams have not advanced beyond the barren areas in which they now terminate, within at least one hundred and fifty or two hundred years. In the case of Davidson glacier, the barren area intervening between the ice and the encircling forest is about half a mile wide. If this retreat was accomplished within one hundred years it would show that the ice foot receded at the rate of about two feet per year.†

Similar conclusions have been reached in reference to other glaciers in the same region and, although definite measurements

*The fluctuations of Great Salt lake have been discussed by G. K. Gilbert, who shows that they coincide but imperfectly with observed variations in temperature and precipitation in the same region. U. S. Geol. Surv., Monograph No. 1, pp. 230-248.

†This is an exceedingly rough estimate for the reason that the breadth of the barren area about the foot of Davidson glacier has not been measured. The statement that it is half a mile wide is from eye estimate simply.

are lacking, these considerations show that the retreat has been very gradual, and was undoubtedly accompanied by many minor changes of which we have no record. The indications are that the retreat of the glaciers has been so gradual that it is doubtful if ordinary weather observations would be able to detect the change, unless carried over a period of several decades, and therefore could not be expected to appear in the weather records now available. For example, a decrease in the mean annual rainfall of the Pacific coast to the extent of one-tenth of an inch per year would, in the time covered by the retreat of the glaciers, produce marked results, but would scarcely be detected in a series of observations covering less than a decade, and even then the stations would have to be numerous to allow one to draw definite conclusions. Similar considerations hold true also in reference to an increase of temperature.

These considerations indicate that the growth of glaciers and the initiation and decline of Glacial epochs, are caused by very gradual climatic changes which would only become conspicuous, as climatic changes are now studied, after the lapse of centuries.

Washington, D. C., February 29, 1892.

EDITORIAL COMMENT.

Sir Andrew C. Ramsay, Bart.

With the death of the late director-general of the geological survey of Great Britain and Ireland, at his home at Beaumaris (I. of Anglesey) on the 9th of December, 1891, at the age of 77, a conspicuous and long familiar figure disappeared from the geological world. A born geologist, he needed only the opportunity for showing his power and this came during a visit to the Isle of Arran (for the benefit of his health, never too strong), through accidental contact with Prof. Nichol, of Glasgow. Mapping and modelling the island, his work attracted the attention of Murchison at the meeting of the British Association, at Glasgow, in 1840. Through his assistance Ramsay was attached to the survey and assigned to South Wales. In 1845 he was made local director for Great Britain, which office he held until on the death of Sir

Roderick Murchison in 1871, he became director general, retaining the post till 1881.

To Ramsay geology is indebted for bringing into prominence the doctrine of earth sculpture. In his first paper on the denudation of South Wales he showed that "the existing topography of the land has a long and interesting history much of which may still be deciphered." This idea he afterwards enlarged in his "Physical Geology and Geography of Great Britain," a series of lectures delivered at first to working-men.

Another of his favorite subjects was the erosion of their beds by glaciers, and the now familiar doctrine of the excavation of the basins in which lie many of the lakes so numerous in glaciated regions. This doctrine yet retains some value in special cases, but it was doubtless pushed by its able author beyond due bounds. He also was among the first to attempt to establish the recurrence of glacial episodes in the distant past, as for example, in the Permian and Devonian eras and to make prominent the idea of palæontological breaks in the record of life, which he did in his addresses before the Geological Society of London in 1863 and 1864, dates which form an epoch in the history of the science.

In addition to these side issues the results of his direct labors may be found in the volumes of the geological survey during his directorship.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Tenth Annual Report of the United States Geological Survey to the Secretary of the Interior. 1888-'89. By J. W. Powell, Director, Washington, 1890. Part I. Geology, pp. xv, 774; with 98 plates, and about 70 figures in the text. Part II, Irrigation. pp. viii, 123.

These volumes were distributed to working geologists and libraries a few months ago. During the fiscal year reported, an aggregate area of 43,222 square miles, including parts of twenty-three states and territories, was surveyed and mapped. The topographic surveys have been extended over the whole of Massachusetts, Rhode Island and New Jersey; more than half of Virginia and West Virginia; approximately two-fifths of Missouri, Kansas, and Arizona; a quarter of Maryland and Tennessee; and a sixth of North Carolina, Georgia, Alabama, Kentucky, and California. About a tenth part of the national domain has been thus accurately surveyed.

Summaries of the work of this survey, and of the present state of knowledge of North American geologic systems, with correlation of formations throughout the country, were in progress of preparation, as follows: on the Pleistocene, by T. C. Chamberlin; Neocene, William H. Dall; Eocene, W. B. Clark; Cretaceous (including the Laramie), C. A. White; Jura-Trias, I. C. Russell; Carboniferous and Devonian, H. S. Williams; Silurian and Cambrian, C. D. Walcott; Algonkian and Archæan, C. R. Van Hise; correlation by vertebrate palæontology, O. C. Marsh; correlation by palæobotany, Lester F. Ward; resumé of North American stratigraphy, W. J. McGee; and discussion of principles of correlation, G. K. Gilbert. Three of these memoirs, by White, Williams, and Walcott, have been since issued as bulletins of the survey.

Professor Pumpelly's report of the progress of his investigation of the structure of the Green mountains shows that they consist of compressed folds overturned toward the west. The cores of the folds are pre-Cambrian crystalline rocks, which are generally hidden. Metamorphosed detrital rocks form the surface, apparently comprising the entire Cambriam system and the Silurian upward to the Hudson River formation.

In the work of the Atlantic Coast division, under the direction of Prof. N. S. Shaler, the morasses and superficial deposits of Massachusetts have been mapped, and are found to exhibit a gradual decrease of stratified gravel, sand and clay, and an increase of the areas of till, in proceeding from the seaboard inland to the western and higher part of the state: moraines have been discovered in the interior, far back from the great terminal moraine which forms the crest of Long Island, and the drumlins are found to display diverse degrees of development, the least prominent grading insensibly into ordinary sheet till.

The structure and origin of the Appalachian mountains have been studied by Mr. G. K. Gilbert and Mr. Bailey Willis, and the latter has undertaken a series of experiments to represent in miniature the folds of these mountains by subjecting layers of plastic material to lateral thrust.

Exploration of the rock formations surrounding lake Superior, by Prof. C. R Van Hise, has been extended over a large area, in northeastern Minnesota and northern Wisconsin and Michigan. For the extensive series of rocks, supposed to be beneath the Cambrian and above the Archæan, well developed in this district, the name Algonkian is proposed. This is another addition to the synonymy of the already burdensome and complicated nomenclature of this uncertain horizon in the geological scale.

In the Glacial division, under the direction of Pres. T. C. Chamberlin, work has related to the glacial Lake Agassiz; to the terminal moraines, and the succession of deposits which make up the general drift sheet: the gravels and sands of glacial origin continuing beyond the limit of the ice incursions in the basin of the Mississipi: trains of boulders in Wisconsin: and the osars, kames, and valley drift in Maine. Reports on most of these subjects are nearly ready for publication.

Dr. A. C. Peale in central Montana, has examined a type section of the entire Palæozoic system from the Carboniferous to the Algonkian, inclusive, finding every principal division distinctively developed.

The field work in the Yellowstone National Park, under the direction of Mr. Arnold Hague, comprised the continuation of observations of the geysers, and especially the careful study of the Excelsior geyser, which, after lying dormant for nearly six years has burst into renewed activity, concurrently with the disappearance of several hot springs and small streams. The topographic maps of the Park, and the delineation of the areal geology, are completed.

Mr. S. F. Emmons has nearly finished the preparation of monographs on the Ten Mile and Silver Creek mining districts in Colorado, and on the Denver coal basin. A most interesting formation, underlying the city of Denver from which it is named, was discovered during the year covered by this report and has been described by Mr. Whitman Cross. It is probably of Eocene age, and consists of sediments eroded from andesitic lavas, but the situation of the area thus denuded has not been determined.

In California Mr. G. F. Becker, spent the greater part of the year in surveys of the Gold Belt, tentatively mapping the geologic formations of about half of the auriferous region. Well-preserved glacial striæ have been found on portions of the walls of the Yosemite Valley, and on the head-waters of the Kaweah river, farther south than any locality previously known. "Here, as elsewhere in the Sierras, the ice marking is wonderfully fresh. Although the streams are roaring torrents of high declivity they have corraded but a few feet of rock since the glaciers disappeared."

Mr. J. S. Diller, in charge of the Cascade division, was occupied during most of the season of field work in the collection of specimens of volcanic rocks from various points of the Cordilleran mountain belt, to form part of a series for distribution to the educational institutions of the country. The number of specimens collected to represent each variety of rock in the series, is 250.

The chief work of Mr. W. J. McGee during the year was the completion of his researches on the Pleistocene formations of northeastern Iowa. Dr. G. H. Williams was engaged in study of the crystalline rocks of the Piedmont region in Maryland; and Mr. L. C. Johnson investigated the Tertiary beds of the coastal plain in the southern states.

This report also reviews the palæontologic work done for this survey by Prof. Marsh, Dr. Newberry, Prof. L. F. Ward, Mr. F. H. Knowlton, Prof. W. M. Fontaine, Mr. C. D. Walcott, Prof. H. S. Williams, Dr. C. A. White, Dr. W. H. Dall, and Mr. S. H. Scudder: the work in the chemical and physical laboratories by Prof. F. W. Clarke, Dr. Carl Barus, and their assistants: the work of the petrographic laboratory by Messrs Diller, Hague, Iddings, Bayley, and others; and the work in mining statistics, and technology by Dr. David T. Day.

The total value of the metallic products of the United States, during 1888 was $256,245,000, of which iron was $107,000,000; silver $59,000,000; and gold and copper, each $33,000,000. Among the non-metallic mineral

products, which had an aggregate spot value of $328,914,000, bituminous coal was $122,000,000, anthracite coal, $89,000,000; building stone, lime, and petroleum, each about $25,000,000; and natural gas $22,662,000. Next to these, but far below, are cement and salt, each about $4,000,000.

The report of the director and the administrative reports of the heads of divisions, which together fill 252 pages, are accompanied by three important papers, entitled, General account of the Fresh-water Morasses of the United States, with a description of the Dismal Swamp district of Virginia, and North Carolina, by N. S. Shaler; the Penokee Iron-bearing series of Michigan and Wisconsin, by R. D. Irving and C. R. Van Hise; and The Fauna of the Lower Cambrian or Olenellus zone, by C. D. Walcott. Reviews of the first and second of these papers were presented in the March GEOLOGIST and of the second in vol. viii, p. 82.

Part II, relating to irrigation, describes the surveys which have been entered upon in the great arid region of the plains and of the Cordilleran belt, with its enclosed basins. The topographic work was in charge of Prof. A. H. Thompson, and the engineering and hydraulic work under Capt. C. E. Dutton.

Mt. St. Elias and its Glaciers. By I. C. RUSSELL. The mist which has so long enshrouded this mountain has been in part dispelled during the past summer by the expedition of Mr. Russell of which he gives an account in the *American Journal of Science* and the *National Geographic Magazine.* Though unable to reach the summit on account of bad weather, he camped with his party at an elevation of eight thousand feet for twelve days, and made one unsuccessful expedition toward the summit, the only one allowed by the weather. Snow also prevented much examination of the rocks but he reports them as consisting for the most part of brown sandstone and dark shale, with intrusions of diorite and a few beds of limestone. The dip is almost invariably to the northeast but the thickness could not even be estimated in consequence of crushing and overthrusts on a grand scale. No clue is given to the geological date of the rocks, but as specimens of shells yet living in the adjoining sea were found in recent strata on the sides of the mountain the conclusion is reached that its elevation must be very recent. Indeed, Mr. Russell says that in his opinion the glaciers took possession of the ground at once, leaving no interval for the action of stream-erosion.

The hight of the limit of perpetual snow is given at 2000 feet and some of the glaciers are fifty miles in length. Many of these unite to form the great Malaspina glacier with an approximate area of 1500 square miles and lying at an elevation of about 1500 feet. This glacier debouches on Yakutat bay and the Pacific ocean between which and the ice intervenes a wide drift-covered area partly overgrown with timber.

Mr. Russell calls special attention in his concluding paragraphs to the marginal lakes which are formed at the hight of a thousand or fifteen hundred feet, wherever the drainage is blocked by the ice and to the deltas and terraces that are formed on the edges by these lakes which will be left, he says, high on the mountain side when the glacier melts away.

The hight of this mountain which has been so long in doubt has been measured by Mr. Russell as closely as was possible with the means at his command, and found to be 18,100 feet, with a possible error of 100 feet. This, with one exception, that of the U. S. Coast Survey, which gave 19,500 feet, is the greatest hight that has been assigned to this peak. Other estimates have varied from 12,672 feet upwards. Its position as determined by Mr. Russell is just within the U. S. frontier and he calls it a corner monument of the national domain.

Parka decipiens by SIR J. W. DAWSON and PROF. D. P. PENHALLOW. In a memoir presented to the Royal Society of Canada this problematic organism is well discussed by both these writers. *Parka* so well named *decipiens* has been an object of controversy ever since its first description in 1831. Regarded by Dr. Fleming as a seed this view was confirmed by later observers, especially by Hugh Miller. Then the opinion was advanced apparently by Lyell, that these bodies were the eggs of some mollusc such as Natica, or of some crustacean such as Pterygotus, the latter of which was frequently found in the same beds. Other writers following these adopted apparently without original investigation, the same view. Having received from Scotland some fresh specimens of *Parka*, these were made the subject of a careful investigation by the two botanists named, and their deliberate conclusion reverses the latter and recurs to the earlier view of their nature. Judging from the statements that they make, and the figures given therewith, little room for doubt remains as to the accuracy of this determination. They make the species and two varieties *media* and *minor*.

In another pamphlet reprinted from the *Canadian Record of Science*, Prof. Penhallow establishes also on material received from Scotland the genus *Zosterophyllum* with one species *Myrtonianum*, found associated with *Parka decipiens* in Devonian rocks, in Caithness. He also describes a *Lycopodites* (milleri) from the same beds.

Prof. Penhallow also describes in the same transactions two specimens of semifossil wood from the Post-glacial beds of Illinois. To one of these he applies the name *Quercus marcyana* from Prof. Marcy of Evanston, who sent him the material and to the other that of *Picea evanstoni* from the place where both were found. The pine occurred in a thin layer of peat immediately overlying the boulder-clay, and apparently in the place of its original growth. The oak lay at a higher level in sand, and had probably been floated to the place. Both trees were in the lowest of the three lake-ridges at Chicago, near the spot from which some years ago the bones of a mastodon were exhumed.

Altitudes between Lake Superior and the Rocky Mountains. By WARREN UPHAM. pp. 229. (Bulletin No. 72, U. S. Geological Survey, 1891. Price 20 cents.) The altitudes of railway stations, summits, bridges, and low and high water of streams are here tabulated, with distances in miles and tenths, compiled from the profiles of about 18,500 miles of railway lines in Minnesota, North and South Dakota, Montana, and portions of

adjoining states, with the entire system of the Canadian Pacific railway, and its connections from Port Arthur to the Pacific. Series of altitudes along the course of the principal rivers are also arranged separately in tabular form, including the lowest and highest stages of the Mississippi and Missouri rivers, during many years at stations along all their course, as determined by the Mississippi and Missouri River Commissions. The basis of reference throughout is the mean sea level.

The Viscosity of Solids. By CARL BARUS. pp. 139: with 6 plates, and 28 figures in the text. (Bulletin No. 73, U. S. Geol. Survey, 1891. Price 15 cents) This treatise is a contribution toward the solution of questions bearing on the viscosity of rock masses, following a general plan devised by Mr. Clarence King. The experimental investigation of the viscosity of steel leads the author to believe that he has discovered a reliable working hypothesis substantially corroborative of Maxwell's theory on this subject.

The Minerals of North Carolina. By FREDERICK A. GENTH. pp. 119. (Bulletin No. 74, U. S. Geol. Survey, 1891. Price, 15 cents.) Since the publication of the latest previous catalogue of the minerals of this state in 1881, there has been great activity in the development of its mining: and by the reopening of old localities and the discovery of new deposits, a considerable number of species have been added. The author states that "minerals formerly supposed to be rare are now found abundantly, and through the recent developments of chemical industry even such unusual species as samarskite, monazite and zircon have acquired commercial importance. For example, in response to an industrial demand, North Carolina has supplied zircon and monazite by the ton, and samarskite by the hundred weight: and the output can be increased almost indefinitely." Many new analyses are presented in this memoir.

Record of North American Geology for 1887 to 1889, inclusive By NELSON HORATIO DARTON. pp. 173. (Bulletin No. 75, U. S. Geol. Survey, 1891. Price 15 cents.) The scope of this record includes Geologic publications printed in North America, and publications relating to North American geology wherever printed. The entries, which are all arranged in a single alphabetic sequence, comprise authors' names, with full titles of separate papers and concise descriptive notes of their contents; titles of journals, state and national government reports, etc., under which authors and short titles of the contained papers are given: and subject references, which are geographic, stratigraphic, and miscellaneous.

A Dictionary of Altitudes in the United States (second edition). Compiled by HENRY GANNETT, Chief Topographer. pp. 393. (Bulletin No. 76, U. S. Geol. Survey, 1891. Price, 25 cents.) This work contains considerably more extensive data than its earlier edition, which was published in 1884: the additions being mainly altitudes determined by railroad surveys. It is also more convenient for reference, as all the points noted

are arranged in a single alphabetic list, instead of the former separate grouping for each state and territory.

Travels Amongst the Great Andes of the Equator. By EDWARD WHYMPER. pp. xxiv, 456; with four maps, 20 full page illustrations, and 118 figures in the text. (New York: Charles Scribner's Sons, 1892.) In this very interesting narrative of the author's mountain climbing in Equador, the geographer, geologist, archæologist, meteorologist, botanist, and zoologist (especially the entomologist), encounter many valuable scientific notes. Mr. Whymper found that a stay during several days at high altitudes accustomed him to endure the rarified atmosphere with less discomfort. Mercurial barometers were used for the determination of the great hights of Chimborazo (20,498 feet), Cotopaxi (19,613 feet), Antisana (19,335 feet), Cayambe (19,186 feet), and the other somewhat less lofty volcanic cones of this portion of the Andes. The best aneroid barometers were found to be very unreliable at the altitude of Quito (9,350 feet), and during all the high ascents, so that they required careful comparison with the mercurial column for learning the irregular variations in their index-errors.

The genus Lituites, Breyn.—Dr. Gerhard Holm publishes in the Proceedings of the Geological Society of Stockholm (Vol. 13, pp. 736 et al.) a valuable contribution to this genus, especially so far as relates to the lobes. He was fortunate enough to obtain some beautifully preserved specimens of *L. lituus* Mont., *L. tenuicaulis* Rem. and some other forms, among which is one new one (*L. discors*). He finds that there are in complete specimens no less than five lobes, with the exception of *L. discors* Holm, in which there are three lobes, and *L. præcurrens*, in which there are only two. There is, however, some doubt about this last species, and it may probably have to be referred to another genus.

RECENT PUBLICATIONS.

I. State and Government Reports.

Indiana. Department of Geology and Natural History. Sixteenth Annual Report. Maurice Thompson, State Geologist. 1888. pp. 472, 10 plates and Natural Gas Map. Indianapolis, 1889.

Bulletin of the U. S. National Museum, No. 42. A Preliminary Descriptive Catalogue of the Systematic Collections in Economic Geology and Metallurgy in the Museum, by F. P. Dewey. pp. 256 with plates. Washington, 1891.

Report on the Coal Measures of the Plateau Region of Alabama, by H. McCalley; with a Report on the Coal Measures of Blount county, by A. M. Gibson, Geological Survey of Alabama. pp. 238, with map and sections. Montgomery, 1891.

Geological and Natural History Survey of Minnesota. Nineteenth

Annual Report, for 1890, by N. H. Winchell. pp. 255 with illustrations. Minneapolis, 1892.

II. Proceedings of Scientific Societies.

The Journal of the Cincinnati Society of Natural History, Vol. XIV, Nos. 3 and 4 contain: Manual of the Paleontology of the Cincinnati Group, by Jos. F. James; Description of some Subcarboniferous and Carboniferous Cephalopoda, by S. A. Miller and Chas. Faber.

Proceedings of the Philadelphia Academy of Natural Sciences, 1891, Part III contains: Notes on some little known American Fossil Tortoises, by Dr. G. Baur; A new Meteoric iron from Garrett Co., Md., by A. E. Foote; Preliminary Notice of some Minerals from the Serpentine Belt, near Easton, Pa., by John Eyerman.

CORRESPONDENCE.

THE DELTAS OF THE MOHAWK.—Pending further investigation, permit me to make the following brief preliminary statement relating to observations bearing on the origin of the terraces of the Mohawk valley and the Iroquois beach.

The terraces of the Mohawk valley are strongly developed, especially along its north or Adironack side. Each terrace is associated with some tributary of the Mohawk. More and longer streams enter from the north than the south, and they flow down steeper slopes and have greater transporting power. Each terrace is built up about the mouth of a stream in the form of a delta, as though the stream had entered a lake or estuary of still water. In a few instances where there is a considerable distance between the larger tributaries there is no terrace. In general, the magnitude of the terraces appears to be proportional to the size of the streams which made them. The long heavy terrace below Herkimer appears to be the delta of Canada creek, which is the largest tributary from the north. This great deposit choked the Mohawk valley from side to side for a considerable distance, and was probably the agent which turned the river out of its old bed and forced it over the rocky ledge at Little Falls a few miles below.

If these terraces are in fact deltas, then the water in which they were made must have been either a lake or a marine estuary. Prof. Merrill has already described estuarine deltas along the Hudson from New York city to Fishkill, rising toward the north, and then again at Albany and Schenectady at an altitude of 340 feet. If the old Hudson marine estuary reached Albany it was probably continuous with the post-glacial submergence of the Champlain basin. In this event it is hard to see how the Mohawk valley could have escaped being a marine estuary also. If it was, then the great deposits near Albany can hardly have been made by the Mohawk, but are probably the delta of the upper Hudson. This explanation comports best with the delta-form terraces of the Mo-

hawk which were plainly formed in the same water body. The upper Hudson is by far the largest stream descending from the Adirondacks and would naturally build a correspondingly large delta.

At Rome the level of the Iroquois beach projected into the Mohawk valley appears to find a perfect continuation in the water-plane in which the terraces were formed. If the Mohawk was a marine estuary and had free connection with the Iroquois basin on the level of its great beach, it seems natural to conclude that the Iroquois beach is also of marine origin. No doubt a great glacier-dammed lake once filled the Ontario basin and had a river outlet past Rome down the Mohawk. But a marine invasion of later date may have obliterated its marks and built up over them the present estuarine deltas of the Mohawk and the Iroquois beach. The fall of 100 feet in the old water level from Rome to Schenectady is not necessarily the fall of a river, but is probably a part of the general northward rise, or a mere local variation. What I have seen thus far indicates that the terraces of the Mohawk are estuarine deltas and not true river terraces. F. BURSLEY TAYLOR.

Fort Wayne, Ind., April 9, 1892.

A Correction. Note on the Paper on Devonian Rocks of Buchanan County, Iowa, in the American Geologist for September, 1891.—In the paper mentioned in the title of this note I made the statement that beds of brecciated limestone lie at the base of the Devonian series in Buchanan county, Iowa, and that this was succeeded by the Independence shales. The Independence shales were originally exposed by putting down a shaft in the bottom of what is known as the old Kilduff quarry, near Independence. In this shaft, beds containing *Gyroceras* and *Gypidula* were found immediately overlying the shales, but none of the beds showed any signs of being brecciated. Beds of brecciated limestone are exposed in the bed of the river below the bridge at Independence, and it was concluded that since no such beds were found above the shales at Kilduff's, the breccia must lie below them. Subsequent observations, made more thoroughly and in detail, revealed this state of affairs: The Gyroceras beds to a thickness of twenty feet or more, have in general, over an area reaching at least from Fayette to Troy Mills, been broken up, and the angular fragments re-cemented to form the brecciated limestone so conspicuous at many widely separated points within the Devonian area of Iowa. The beds affected were not entirely converted into breccia, for it is occasionally found to be the case that over patches several rods in diameter the Gyroceras beds, with their associated layers, retain their original position undisturbed. It would seem that the shaft at the Kilduff quarry passed through one of these undisturbed patches, and so led to the conclusion that the breccia exposed at the bridge in Independence could not be above, but must lie beneath, the shales. Those who are interested will kindly note this correction in connection with the article in the GEOLOGIST, Vol. VIII, p. 142.

A few points have been found where the shales, by a little digging, may be seen beneath the breccia. S. CALVIN.

PERSONAL AND SCIENTIFIC NEWS.

TOPOGRAPHIC MAP OF THE UNITED STATES.—Mr. Henry Gannett. Chief of the Topographic work of the United States Survey. is the author of an elegant suite of maps of the United States recently printed by the survey. Last year he issued a limited edition of a large map of the series in nine sheets, which recently have been reprinted in a reduced scale of 30x20 inches upon a single sheet.

The map is intended primarily to show the hypsometric and drainage features of our country, with a minimum of political features, only sufficient to enable the natural features to be located. The altitudes are shown by contour lines printed in brown, the streams in blue and political features in black. Various editions are issued showing either one, two or all these features, and are artistically and beautifully printed.

These maps are an invaluable addition to the cartography of our country, not only for their educational value, but as appropriate bases for the platting of physiographic and geologic data of every kind, and Mr. Gannett has done a service to science by their preparation.

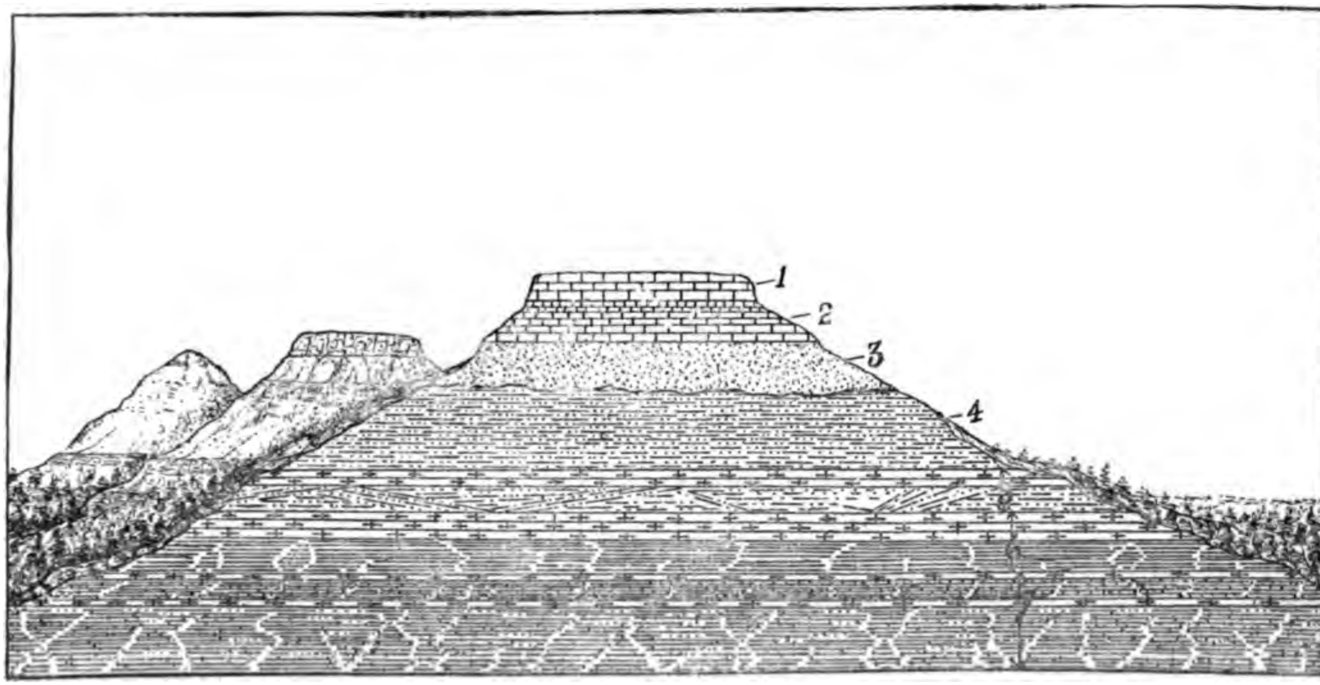
PROF. H. S. WILLIAMS, professor of geology at Cornell University has accepted the chair of geology at Yale University.

PROF. JAMES E. TODD, OF TABOR, IOWA, has been elected professor of geology and mineralogy at the University of South Dakota, Vermillion.

MR. ROBERT ETHERIDGE, WELL KNOWN by his paleontological labors during many years of active work on the geological survey of Great Britain, has retired with well-earned honors, and his place as assistant keeper of the geological department of the British Museum has been filled by the appointment of Mr. A. Smith Woodward, author of the catalogue of fossil fishes in the British Museum. Mr. Woodward's name is already well known among paleontologists in America, as he visited this country about two years ago, and remained for several months.

A GEOLOGICAL SURVEY FOR IOWA has been provided for by a bill recently passed by the State Legislature. For the support of the survey for the next biennal period the bill appropriates twenty thousand dollars. The Geological Board will consist of the Governor, the State Auditor, the President of the University, the President of the Agricultural College, and the President of the Iowa Academy of Science.

A COURSE OF UNIVERSITY EXTENSION LECTURES on *World Making* has been given at Davenport, Des Moines and Iowa City, by professors from the State University of Iowa. The success attending these lectures shows that the intelligent public may easily become deeply interested in geological problems.



... OF DOUBLE MOUNTAIN, STONEWALL COUNTY.

THE

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THE DOUBLE MOUNTAIN SECTION.

(PLATE VIII.)

By E. T. DUMBLE and W. F. CUMMINS, Austin, Tex.

In pursuance of the work of the survey, in making a section across the Permian strata of Texas, we left Abilene early in October, 1889, and traveled north and a little east to the contact of the Carboniferous and Permian, on the Clear fork of the Brazos in Throckmorton county. From here we turned directly west crossing the Permian beds to the Double mountains, where we expected to find the contact between the underlying Permian and any Triassic or Jurassic beds which might occur, and the overlying Cretaceous. While we found no Jurassic, the section of these mountains is nevertheless of interest, since it is the most northern point in this northwestern portion of the state at which the beds of the Lower Cretaceous are exposed, and the most easterly exposure of the Trias which we have been able to recognize.

The Double mountains are situated in the southwestern corner of Stonewall county between the Double Mountain fork and the Salt fork of the Brazos, just south of the thirty-third parallel of latitude, and in longitude 100° 25'. They consist in reality of three peaks or buttes, one of which, however, is so situated with reference to the other two as to be invisible on the approach from the southwest in consequence of which they have received their name. Two of the peaks present the usual butte structure so characteristic of the Cretaceous hills, when capped with the Ca-

prina limestone. The third, however, is a true peak in form. the hard limestone having been eroded from its top. Lower down the different beds of massive gypsum form benches around the side of the mountains and the clays which form their bases have been washed into innumerable canons which are often entirely impassable.

Salt creek, a branch of the Double Mountain fork, is located about four miles east of the mountains. From this creek, which is the beginning of the ascent, to the summit of the highest peak, is by barometric measurement eight hundred and forty-five feet, of which amount three hundred and twenty feet are passed before the ascent of the mountain proper begins, giving it an elevation of five hundred and twenty-five feet above its immediately surrounding country.

Climbing the successive ledges of sand, gypsum, clay and limestone until the summit of the mountain was reached, we obtained a view embracing many miles of the country. It stretched out before us gently undulating, open, without timber save here and there a scattering thicket of mesquite. The Salt fork to the north and the Double Mountain fork to the south wound their ways eastward toward their junction as slender threads of yellowish red. Very few evidences of settlement were to be seen. On the flats were many water-holes filled by the recent rains, and cattle could be seen scattered here and there in all directions. To the south, probably as much as twenty-five or thirty miles, a series of flat topped hills were seen stretching along the horizon, while to the west, at a very considerable distance, there were three or four buttes of similar form to that on which we were standing, and which we took to be Mt. McKinzie and its neighbors. These were backed by the blue scarp of the Staked Plains. Kiowa peak, some thirty miles to the north, was invisible.

GENERAL SECTION.

Section of the eastern peak of Double mountain, beginning at the top:

Lower Cretaceous	1. Caprina limestone	40 feet
	2. Comanche Peak series	55 "
	3. Trinity	25 "
Triassic	3a. Dockum	35 "

PERMIAN	4. Shaly clay, underlaid by red or terra-cotta sandstone	105 feet.
	5. Upper Gypsum beds	60 "
	6. Middle Gypsum beds	75 "
	7. Lower Gypsum beds	135 "

CRETACEOUS.

1. Caprina Limestone.

The Caprina limestone which caps the mountains has a total thickness of forty feet. It is deeply fissured in places, and the rapid erosion of the softer underlying materials has scattered its debris down all sides of the mountain. In structure, it presents the usual characteristics of this limestone and on the surface often shows a ferruginous weathering of the *Caprina* so common in western Texas. The rock in this locality contains many *Hippurites* of large size, and the *Caprina* forms found in it are varied and some of them heretofore unknown. They have, however, since been found in rocks of the same horizon, in an exposure on Barton creek near Austin, and also at other localities in Western Texas.

2. Comanche Peak Series.

The rocks of the Comanche series are here separable apparently into three distinct divisions, the upper of which is a series of impure argillaceous limestones having an entire thickness of twenty feet, the top being much more shaly than the bottom. The fossils are very numerous and well preserved, but diligent search failed to show a single *Gryphæa pitcheri* in it. The second division is somewhat similar in composition but more indurated and is of a yellow color. Some of the fossils in this bed had been altered into calcite. In it we found very few specimens of *Gryphæa pitcheri*. The third division consists of a shaly limestone containing a great abundance of very small fossils overlying a marly limestone, which is in turn underlaid by the Gryphæa conglomerate, which here as elsewhere is almost a solid mass of individuals of this species. The fossils throughout are abundant and well preserved, and correspond in the main with those of typical sections farther east.

3. Trinity Beds.

Immediately underlying the *Gryphæa* conglomerate is a bed of yellow sand about ten feet in thickness, which at the time of making the section was considered as the upper portion of the

Trinity sands. It differed, however, from the beds previously referred to this horizon in Texas, in the fossils which were found in it. These consisted of an oyster which differed from *O. franklini* Coquand, and is now recognized as a new species, *Pleurocera strombiformis* Schloth, *Exogyra texana* Roemer, *Gryphæa pitcheri* Mort. The association of these fossils in this way had not been reported previously, and in order to be certain of their existence together in the same stratum we dug into the bed far enough to prove it absolutely. Since later investigations have shown the "Alternating Beds" to be a part of the Trinity sands, and *the* fossiliferous part, and that at their thinning out on the northern border the fossils still continue for a limited distance in a calcareous sand, this bed would seem to indicate a similar condition at this locality, and that it should be referred to the "Alternating Beds" of the Trinity division. Otherwise it would appear to be a transition bed between the Trinity sands and the Comanche group.

Underlying the yellow sand are twelve feet of purple and mottled sand which are very gypsiferous, and below them we find a bed of cross bedded indurated sands. A few bright colored pebbles are scattered through this bed and seem to be of somewhat larger quantity toward the base. In this bed are also found the botryoidal layers of sandstone so often observed in the same beds to the east.

3a. Triassic.

The basal crossbedded sands of the Trinity rest with slight unconformity upon a series of purple, red and mottled sands which pass at the bottom into a conglomerate of bright colored pebbles. The same bright colored pebbles are found scattered through the bed from bottom to top singly and in nests or even forming thin strata in places. Although in the original section it was referred to the Trinity, the character of the material is now known to be identical with that described under the name of Dockum beds in the first annual report of this survey, and it is, therefore, referred to the Triassic, although we were unable to find fossils at the Double mountain locality such as occur in the beds near Dockum.

These beds have a total thickness of thirty-five feet.

All of the deposits included in the Triassic and Cretaceous have a slight dip towards the southeast.

4. Permian.

Underlying the conglomerate last mentioned but separated by a bold unconformity we find five feet of shaly clay dipping toward the northwest. It is underlaid by a red or terra-cotta sandstone somewhat mixed with clay toward the top and bedded in layers which vary in thickness from one foot to an inch or less. There are one or two thin seams of impure limestone imbedded in the sand, but although most careful search was made for fossils none were found.

5. Gypsum Beds.

The red, or terra-cotta, sandstone rests directly upon the upper gypsum beds which consist of an upper layer of gypsum underlaid by yellow and red sandy clays or shales which are much cross bedded. Gypsum also occurs throughout the clays.

6. Middle Gypsum Beds.

These consist also of an upper layer of massive gypsum more than ten feet in thickness, which is underlaid by a series of red and blue gypsiferous clays and shales.

7. Lower Gypsum Beds.

Massive and shaly gypsum varying in color from white to rose red, underlaid by thin bedded sandy clays and shale with gypsum.

There was some difference in dip noticed between the three beds of gypsum. However, with the amount of detritus which occurs on the side of the mountains and the constant suberosion which is going on, such appearances cannot be taken as representing the true dip of the beds, which all dip probably to the northwest, except the Triassic and Cretaceous which dip distinctly to the southeast.

No beds were found which could in any way be referred to the Jurassic and since the accumulation of evidence seems to be in favor of the retention of the Trinity in the Cretaceous system in spite of the Jurassic affinities of certain of its ostrean forms it would seem that deposits referable to the Jura are entirely wanting in Texas, at least east of the Pecos river.

PROF. I. C. WHITE'S "STRATIGRAPHY OF THE BITUMINOUS COAL FIELD OF PENNSYLVANIA, OHIO AND WEST VIRGINIA."

JOHN J. STEVENSON, New York.

The geologists of the first geological survey of Pennsylvania labored under very serious disadvantages in the western part of the state; they had no barometers, not even good Locke's levels: much of the country was still wilderness; there were no railroad cuttings; even the cuttings made for the turnpikes had become covered with debris or sod; coal shafts, except near Pittsburgh or some other large city were unknown; records of borings were undreamed of; where twenty coal pits are open now, there was barely one then. Remembering these disadvantages, we are not surprised by defects found in the work of the older geologists, but we are astonished at the wonderful skill with which the structure was worked out and at the accuracy characterizing most of the detailed examinations. But too often the distance between one good section and the next was so great that identifications were sometimes made at hazard, so that a feeling of uncertainty prevailed respecting the true relations of different parts of the Coal Measures column.

For this reason, prior to the work of the second geological survey of Pennsylvania, great difficulty was experienced in making comparisons of the Ohio, Pennsylvania and West Virginia sections: Newberry made identifications of the lower coals of Ohio with the lower coals of Pennsylvania; the writer did the same for the upper coals of those states and offered some suggestions respecting the relations of the West Virginia beds to those of Pennsylvania. The groupings and identifications were quite as good as could be expected under the circumstances; for which reason, doubtless, they have been permitted to rest in the peace of oblivion for about twenty years. But the excellence of the work done by the older Pennsylvania geologists as well as by those of the Ohio survey was discovered when the 2d Pennsylvania survey undertook the correlation: for, after Prof. I. C. White had completed the work along the state line and had corrected the defects in the work of those who had preceded him, he found no difficulty in utilizing the material gathered by his predecessors. His memoir, lately issued as a bulletin of the U. S.

geological survey, is merely a more extended bit of work like that done for the Ohio state line in Pennsylvania.

This synopsis of the bituminous coal field is no mere compilation. Prof. White's work began in 1875, when, as the writer's aide on the 2d Pennsylvania survey, he worked out the highest rocks of the Appalachian area, and secured the knowledge which has made him an authority on the series above the Pittsburgh coal bed; afterwards he unraveled the tangle along the state line; his economic investigations in later years compelled the underground tracing of the beds in oil-borings and the study of outcrop lines and cross sections in West Virginia far more in detail than could be required under ordinary conditions. To utilize his material it was necessary to connect with the Ohio survey and to make use of its work. The compact statement before us presents the summary of facts obtained during fifteen years of field work.

The author's division of the Carboniferous into

Upper, with alternations of fresh and brackish water,
Middle, with alternation of marine and freshwater conditions,
Lower, wholly marine.

answers well for the greater portion of the Appalachian area and appears to answer, with rare exceptions, for the region under consideration, the only exception being in southwestern Pennsylvania, where marine fishes found their way far north at a late date; but this cannot be regarded as militating against the general conditions described by Prof. White. The memoir treats only of the Upper and the Middle Carboniferous, which are divided into;—

XVI. Permo-Carboniferous—Dunkard Creek series.
XV. Upper Coal Measures—Monon ahela River series.
XIV. Barren Measures—Elk River series.
XIII. Lower Coal Measures—Allegheny River series.
XII. Pottsville Conglomerate.

The line between Middle and Upper is drawn almost midway in XIV, the Lower Barren Measures of the older geologists. The grouping is that presented by the Rogers brothers more than half a century ago.

A chapter is devoted to each series, in which Prof. White gives a resume of characteristics of the series as a whole, which is followed by vertical sections, so numerous and in such detail as to leave no room for doubt as to the accuracy of the identifications. The last portion of the chapter describes the more important members of the series.

The discussion of the Permo-Carboniferous is based chiefly on studies made in Pennsylvania and West Virginia, the references to Ohio sufficing merely to show the extent of the area in that state. The remarkable flora in the roof shales and partings of the Waynesburgh coal bed in southwest Pennsylvania and the northern part of West Virginia is briefly described. It was determined by Fontaine and White, who showed its intimate relation to the Permian flora of Europe. The exact relation of this upper portion of the Appalachian column to the section west from the Cincinnati axis has yet to be determined; and the problem is complicated in many ways. The writer is inclined to think that the Permo-Carboniferous beds of southwest Pennsylvania are contemporaneous with the upper part of the Upper Coal Measures within the Mississippi-Missouri region as well as with the Permian of Texas. Long after the appearance and after the practical disappearance of this flora within the Appalachian region, an incursion of the sea brought Rhizodus from the outer ocean, so that scales of that fish are abundant in the shales accompanying the Blackville limestone at 120 feet above the Waynesburgh coal bed. But this in no wise affects the cardinal point in the case: the presence of the plants attests that a portion of the Upper Carboniferous in this area is contemporaneous with the Permian of Europe, in so far as the testimony of plants can be taken in detail respecting a time when passage from the old into the newer had begun. So that now, there can be no doubt that our American Carboniferous represents the whole of the age as known in Europe, though, apparently, no change occurred in the American ocean or seas such as to justify the separation of the Permian as a distinct division of equal importance with our lower or upper Carboniferous.

Prof. White's grouping of sections shows noteworthy variations in the southern limits of the principal beds of the Upper Coal Measures. The southern limit of the Pittsburgh and Waynesburgh practically forms a northward loop around the Volcano anti-cline, so well known as the line along which oil wells have been productive in West Virginia and Ohio for more than twenty-five years. The series is persistent here but the coals are wanting. The sections of the Lower Coal Measures show a similar east and west loop in the Upper Freeport extending from Lawrence county of Kentucky into Raleigh county of West Virginia.

The Barren Measures receive careful treatment; the description

shows remarkable uniformity of the general conditions over a great area, for the total thickness varies little in the southern counties of Pennsylvania and for a long distance southward in West Virginia; while the more important beds are as persistent as similarly important beds in the Lower Coal Measures; at the same time the thickness of intervals and the character of the rocks filling them show changes more abrupt and more striking than can be observed in any other portion of the column.

The details respecting the Lower Coal Measures and the Conglomerate Measures are of the utmost interest; some of the identifications in West Virginia are startling, but there seems to be no ground whatever, for taking exception to their accuracy. Nearly all of the material respecting West Virginia is new.

But it is impossible within the limits of a notice to give a synopsis of a memoir, which is itself synoptical, a series of presentations rather than a series of discussions; so that those interested in the bituminous area must be referred to the memoir itself. Those who have much to do with economic work will find this a more than useful handbook to expedite their explorations; those who have made careful studies in detached portions of the area will feel grateful for the systematic joining of those portions, even though it be done at the sacrifice of some cherished conjectures. Prof. White's treatment of his colleagues in this field is sufficiently comforting; he has ignored our faults and has observed our virtues—more than once to the extent of labeling good work of his own with the name of another.

NOTE ON THE DIFFERENCES BETWEEN ACERVULARIA PROFUNDA HALL, AND ACERVULARIA DAVIDSONI EDWARDS AND HAIME.

By S. Calvin, Iowa City.

The original description of *Acervularia profunda* Hall is found in Hall's Report on the Geological Survey of Iowa, published in 1858. The specimens on which the species was founded came from near Independence in Buchanan county, Iowa. In the same report professor Hall, not without some hesitation, identifies another form found abundantly throughout the Devonian area in Iowa, with *Acervularia davidsoni* Edwards and Haime. This, so far as I have been able to ascertain, was the first time the name

had been employed in a work published in America; for although Edwards and Haime's specimens came from near Jeffersonville, Indiana, the description of *Acervularia davidsoni* appeared in the great monograph of the authors, published in France.

It should be noted that near Jeffersonville, Indiana, there occurs another form which authors, following the example of Edwards and Haime, usually refer to *Cyathophyllum rugosum* Hall.

The three species mentioned above, as recognized by every one who has handled them, are somewhat closely related. Dr. Rominger in Geology of Michigan, Vol. III, page 107, is disposed to regard them all as but varieties of one species. The *Acervularia davidsoni*, as it occurs in Iowa is somewhat sharply defined from either of the other two, while *A. profunda* exhibits a very intimate correspondence as to structure with *Cyathophyllum rugosum* from the falls of the Ohio.

Comparing *A. profunda* with *A. davidsoni* we may note that it differs in the appearance and mode of growth of the corallum, in the greater tendency to independent grow h of corallites, in the size of the corallites, the shape of the calyx, the thicker, non-corrugated wall by which the individual corallites are bounded, the almost entire absence of an inner pseudo-wall defining a central area, and the thinner septa with more numerous and more conspicuously developed carinæ.

The *A. profunda* is a much coarser looking species than *A. davidsoni*. Its lower surface is never as smooth and flat as is that of most coralla of the other species from Iowa. This surface is traversed radially by the outer corallites which stand out as strong transversely wrinkled ridges, sometimes almost entirely free from union with contiguous corallites. All the corallites show a remarkable tendency to independent growth, so that in some specimens a large proportion of the whole number of corallites stand apart on the upper surface of the corallum from those adjacent, and are individually covered externally with an independent epitheca. In certain modes of preservation the corallites are even separable into wrinkled, polygonal prisms that exactly imitate a very common condition in *Cyathophyllum rugosum*.

In the region from which Hall's type comes, the corallites of *A. profunda* are on the average somewhat larger than those of *A.* davidsoni. It is true that the corallites of both species vary within very wide limits, and it is therefore quite possible that the

superiority in size of *A. profunda* may not be maintained in all localities. In the Paleontology of Ohio, Vol. II, page 240, Dr. Nicholson describes a form under the name of *Acervularia profunda* Hall. that is distinguished among other things by having the corallites smaller than in *A. davidsoni*.

The shape of the calyx is markedly different in average specimens of the two species. In *A. profunda* the calyces are separated by relatively thin partitions owing to the manner in which the sides of the cup slope abruptly downward and inward from the margin; the septa are thin and have conspicuous, crowded carinæ which are as fully developed near the margin of the calyx as around the central area, particulars in respect to which they are in marked contrast with the septa of *A. davidsoni*. The septa differ still further from those of *A. davidsoni* in having more of their edges free and in having their edges beautifully denticulated. There is but little thickening of the septa to form a pseudo-wall around the central area; indeed this feature is, in a very large proportion of cases, wholly wanting. The secondary septa are nearly as long as the primaries and often become coalesced with the primaries inside the central area.

Acervularia davidsoni Ed. and H., has a much wider geographical range in Iowa than *A. profunda* Hall. The area in which *A. profunda* occurs is nearly all included in parts of Buchanan and Blackhawk counties, while the area over which the other species is distributed is many times greater. As pointed out in the GEOLOGIST for September, 1891, *A. profunda* is not associated in the same beds with *A. davidsoni*, but occurs uniformly at a horizon a few feet lower. Outside the area occupied by *A. profunda* its place seems to have been taken by *Phillipsastrea gigas* Owen. At least this last species, while never very common, occupies the same relative position a few feet below the horizon at which *A. davidsoni* is found, and so far as known it is not present in the region in which *A. profunda* attains its maximum development.

With respect to the particulars in which *A. profunda* differs from *A. davidsoni* it agrees essentially in structure with *Cyathophyllum rugosum* of authors, and it may therefore be regarded as the western representative of the last named species. If carinated septa have any generic significance, then *Cyathophyllum rugosum* is certainly not a *Cyathophyllum* at all. Whatever may be the significance of the carinæ and other peculiarities of struct-

ure, *C. rugosum* and *A. profunda* must ultimately stand side by side in the same genus.

Acervularia davidsoni stands somewhat apart from both of the foregoing species in a number of particulars. The calyces have a sharply defined central pit with explanate margins. In typical specimens the floor of the calyx, except in the central pit, is almost on a level with the margin; the septa are thick, scarcely denticulated, with but a small portion of their edges free; the carinæ are few and clumsy and chiefly developed in the region immediately surrounding the central area. Around the edge of the central area both primary and secondary septa are conspicuously thickened, the carinæ are also developed there better than elsewhere, the effect being to produce in polished sections the appearance of a bi-areal coral with a central area bounded by a definite inner wall. Under the magnifier this wall is never complete. The thickened septa and strongly developed carinæ never quite coalesce, so that the outer area is never, as in true bi-areal corals, perfectly shut off from the central space. At the margin of this central space the secondary septa all end more or less abruptly, and only the primary septa are continued as thin non-carinated lamellæ into the central area.

Acervularia davidsoni is certainly con-generic with some of the species referred to *Acervularia* by Edwards and Haime and other authors. Whether or not it is generically related to the type species of the genus may be left an open question. So long as genera are mere artificial creations, without sharply defined natural boundaries separating one from another, it will do no violence to facts, but will be a matter of convenience and at the same time give effect to a recognizable structural difference, if we keep *A. davidsoni* apart from typical forms of the genus *Cyathophyllum*,* and for the present at least retain it in the genus *Acervularia*. Along with *A. davidsoni* must go *Acervularia inequalis* Hall and Whitfield. Simply as a matter of convenience, but with less confidence as to the justness of the arrangement, we may add to the recognized species of *Acervularia* the *A. profunda* Hall, and the *Cyathophyllum rugosum* Hall, as recognized by so many authors. The last two may yet, with perfect justice, be separated generically from *A. davidsoni*.

*Dr. Rominger and Mr. W. J. Davis place this and related species under the genus *Cyathophyllum*. See *Geology of Michigan*, Vol. III, and *Kentucky Fossil Corals*.

THE KAWISHIWIN AGGLOMERATE AT ELY, MINN.

N. H. Winchell, Minneapolis.

It has been stated that the gneisses and schists of the Archæan, in Minnesota, terminate upwardly by a great non-conformity with the overlying Taconic. It has also been shown that the uppermost member of the Archæan is the Keewatin, a series of schists, graywackes and variously reconstructed gneissic rocks. It has been shown, further, that the youngest member of the Keewatin is the pronounced "greenstone" stage, in which occur the iron ores of the Vermilion iron range in Minnesota. This phase of the Keewatin has been designated specially *Kawishiwin* from the Kawishiwi river, on whose upper courses these rocks are exposed in favorable position for study. It has also been shown that these rocks have been subjected to great pressure, upheaval, shearing and fracture, resulting in very tortuous structures and complication of physical features.

It has been a subject of much study and no little variety of opinion, as to the origin of these greenstones,—are they plutonic rocks that have been subjected to "dynamic metamorphism" and thus caused to show the semi-decayed conditions that mark their mineral constituents, or are they sediments consolidated or "metamorphosed" so as to have lost their original structures and composition? Or, again, are they the result of a "crenitic" process, as suggested by the late T. Sterry Hunt, by which they are the reliquiæ of mineral waters circulating through the crust of the earth, left at the surface on evaporation? Or are they the remnants of the primary basic doleritic crust of the earth, produced by the solidification of the primeval molten mass?

They are not the remnants of the first cooled doleritic crust because they are younger than all the other stratigraphic parts of the Archæan. They are separated by many thousands of feet of strata from the basal gneisses which are called distinctively Laurentian.

They are not "crenitic" rocks, if the acid basal gneisses are crenitic, for they contain in predominating amounts those very elements which are first and easiest dissolved by heated waters, and which could not be left as reliquiæ on evaporation—and also because in order to form *these and the acid basal gneisses* there would have to be a reversal of the respective solubilities of the acidic and the basic minerals concerned, between the date of the formation of the gneisses and the date of the greenstones, which is

hardly supposable in the light of the constancy of chemical affinities.

We are driven back therefore to the same long-contested field for which the neptunists and the plutonists have contended since the days of Werner.

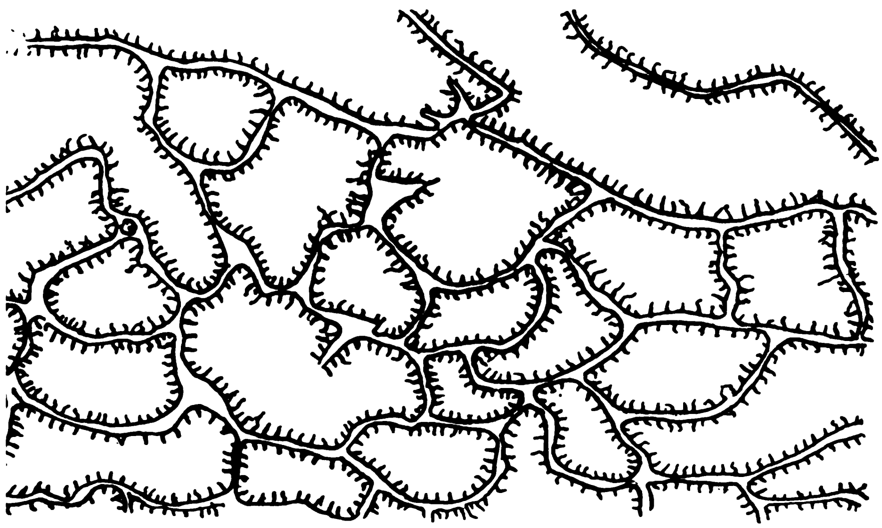
In recent years a new phase has been put on this controversy. Like some other long-disputed questions it appears that it is likely that there is truth on both sides, and that complete harmony may be effected, perhaps, by a little compromising acknowledgement of wrong by both of the adversaries—or at least by the acknowledgment of right in each. There has grown up a more perfect knowledge of the nature of rocks since the microscope has been introduced into lithology. Various differentiating characteristics have been established by which an unquestioned classification can be predicated, thus determining the origins of some rocks which before had been problematic. At the same time more careful field-work has been conducted in the crystalline rocks. Their major field-structures have first been correctly delineated. On this as a basis the microscope has laid out its minuter subdivisions, in a manner somewhat like the minuter classifications established by the paleontologist. The field-structures must be determined first, for it is not possible for either microscopy in the crystalline rocks or paleontology in the later rocks to take independent initial cognizance of this. Their data are of subordinate importance, and are of value only as they can be grounded on foreknowledge of the actual structural features. Whether the Olenellus fauna preceded or followed the Paradoxides fauna in America could not be decided till a field examination was made in Newfoundland. The strata there revealed the Olenellus fauna anterior to the Paradoxides fauna, thus in effect reversing the conclusions which had been reached through paleontological reasoning alone. In the same way the fact that a rock is eruptive is obtained in the first instance by field evidence—never by microscopic examination. Once the microscopic characters of a known eruptive rock being ascertained, those characters are good for the indication of a problematical eruptive rock *so far as those known characters extend*, but no further. If the known characters fail, and especially if adverse characters are brought to light, it is the part of caution, as well as of wisdom, to withhold a decision as to the origin of such a rock until new light can be reached.

The Kawishiwin greenstones most perfectly illustrate these principles, for there can be no question but that they are the northern representatives of the greenstones, or green schists, of the southern side of lake Superior, and of more eastern localities. The greenstones are a well known great series of Arcnæan rocks, and they have been studied by many eminent geologists, both in America and in Europe. Their stratigraphic position in the Archæan has been made out. with substantial concord, in several European countries and in various parts of America. Geologists have divided, however, on the question of their origin, as already intimated, and at the present day the lines lie substantially where they did one hundred years ago—between the plutonists and the neptunists—but the disagreement in general has been reduced to a much smaller limit, and involves fewer varieties of rock than one hundred years ago. Then basic dikes, for instance, were claimed by both parties, but now are given up to the plutonists. Then all the granitic, or crystalline rocks, including the bedded schists, were claimed by both, but now the bedded crystalline schists are given up to the neptunist. Then all crystallne iron ores were claimed by both, now they are divided between them. As the field has narrowed the contest has deepened, not in the personal animosities and epithets that marked the early disputants, but in the acumen and watchfulness and the industry of the parties engaged. According to structural evidence the neptunist asserts that the greenstones cannot be relinquished from his ownership, but he has to admit that his claim loses some of its validity when his evidence fades out and some new adverse claims confront him. He sees the stratification which has been his guide in ten thousand instances, lose some of its marked characteristics, and finally disappear or show itself faintly under some disguises, and so long as his known characteristics of neptunic rocks are not legible in these he has not a clear title, and he has to admit it. On the other hand the plutonist, microscope in hand, declares that the mineral composition is such that the constituent grains must have come from eruption, and could not be the result of ordinary erosion and sedimentation. This claim is based on a familiarity with the elements of known eruptive rocks from other localities, and it cannot be safely disputed. But the student of the physical structure returns to the argument by pointing to the remnants of stratification, and to the occasional occurrence of

rounded grains of quartz. The microscopist makes his rejoinder that these remnants of stratification are illusive, due to dynamic metamorphism, and the quartz grains are of secondary origin. He further cites, as evidence of dynamic agencies in the origination of those structures, the semi-decayed and broken condition of the other minerals. There are curious fractures in some of the mineral grains. They appear to be "streamed" out in the direction of the schistosity. The feldspars are saussuritized, the hornblendes are chloritized, the augites are converted by a well known alteration to hornblendes, the micas are hydrated and the menaccanite is changed to leucoxene. A dynamic metamorphism has produced a degradational change throughout the whole rock. This indicates that while the materials had originally unquestionably an eruptive origin, as denoted by their identity with other changed known eruptive minerals, they have been subjected to some grand force or forces of pressure and shearing, which have wrought a profound alteration in them, bringing them a step, or a long march, toward decay and disintegration. The microscopist admits that his well-known and infallible guides are wanting. He sees nothing, or very little, of the "diabasic structure," and the freshly crystalline interlocking of the constituent grains which characterizes an unquestioned eruptive rock, is almost entirely wanting. His title therefore, as it is not based on characters which known plutonic rocks possess, but on others which he assumes to be due to another and a later cause, is defective, and he has to admit it. If the features which the interior of the rock exhibits can be ascribed to neptunic forces, as claimed by his opponent, the case is still a drawn game, unless there are inherent faults in the reasoning of one or the other—such that they can be pointed out and demonstrated.

The purpose of the foregoing is to introduce a peculiar feature seen by the writer at Ely, on the Vermilion iron range, in Minnesota. The country rock here is the characteristic greenstone of the region, massive, shapeless, rather light-colored, embracing scattered grains of free quartz so as to present sometimes a rough and harsh exterior on weathering, and having a gradual transition northward across the formation, first into a green schist, then into graywacke and lastly into a sericitic schist. With this transition there is developed a sedimentary structure which in its final condition is undeniable, the schist element becoming interbedded

with regular siliceous layers which fade out and increase across the bedding in the manner of sedimentary alternations in any paleozoic rock. In the midst of this prevalent greenstone appears a spottedness, revealing included rounded masses of rock quite like the greenstone itself in general aspect, some of the rounded masses being from 6 to 10 or 15 inches in diameter. They are densely packed together, but make up the mass of the rock. Such characters have been seen in many places in northern Minnesota, and are particularly developed in the Ogishke conglomerate; which really runs many miles in this formation, and can be traced from Ogishke Muncie lake to and beyond Tower. It is in the midst



of this greenstone agglomerate that the jasperoid iron ores occur throughout the Vermilion range. This agglomerate passes by easy transitions into real conglomerates, but in that case the pebbles are smaller, and are also sometimes much more siliceous.

At a small railroad cut within the town limits of Ely, a few rods west of the Chandler mine, these rounded masses are conspicuously displayed, by reason of the dome-shaped form of the exposed rock, and the uniform glaciation which has left the surface planed off, revealing distinctly the forms of the boulders or bombs. This cutting was seen soon after the construction of the railroad, and has been inspected several times since. On one occasion a drawing was made which is reproduced above. This

shows the upper surface of the natural rock as it appears after the glacial planing, and includes a surface about five feet long.

The rounded forms are encased in a darker green and evidently somewhat chloritic, fine-grained schist, which winds about among the rounded masses, its fibrous structure coinciding in direction with the surfaces with which it is in contact. This green schist cannot be distinguished from that which is common at all of the mines of the region and which ordinarily constitutes the country rock about the Tower mines. It is presumable that there are places in this agglomerate where this green schist is lacking. and the rounded masses are in absolute contact, but the drawing. rather hastily made, was designed to bring out the appearance of the pipe-shaped, calcite-filled, amygdaloidal structure, and this point was neglected. The rounded bodies here represented are not evidently of igneous rock, but rather approximate that indefinite greenish rock styled porodyte by Dr. M. E. Wadsworth. They contain no evident free quartz,* neither do they contain *per se* anything else that is evident. They are referable to a consolidated pulp made up of comminuted grains of eruptive rocks but having evidently a greater per centum of silica than ordinary basic eruptives. A few fine pyrite cubes are discoverable, and on being powdered the rock has a quick, slight effervescence with hydrochloric acid. The stones have a pale, dun-green color, are very fine-grained, and might, with a broadened significance to that term, be called felsyte. They lack evidently the orthoclastic element which is essential to true felsyte.

The most remarkable character of this singular rock is yet to be described, viz: About all the peripheries of these rounded masses of porodyte are tubes, standing perpendicular to their surfaces and separated, on an average, about one-quarter of an inch from their neighbors. These tubes, which are normally filled with calcite, are sometimes more than an inch in length, but most frequently are less than an inch. They stand perpendicular to the bounding outer surfaces of the rounded masses. They do not enter at all, or but slightly, into the darker green schist which is wrapped about the masses. They are approximately circular or pipe-like, and their diameter is about two millimetres. Some of them, however, are a little zigzag, and roughened in their inner

*In one instance a siliceous pebble, about one-eighth of an inch in diameter, is seen embedded in this porodyte, in specimen No. 1624.

surfaces. This is revealed by fractures across them after the calcite has weathered out, which is the case in many instances. While these tubes are generally simple, and approximately round in section they are not always so, but they flatten out for a short space and return again to the pipe-stem shape, and sometimes they branch, or coalesce, and so far as observed they branch like a plant upwardly, or outwardly, *i. e.* toward the exterior surfaces of the rounded masses.

Calcite is also common in the green envelope which surrounds these masses, but it is arranged in flattened, thin, lenticular sheets conformable with the fibrous structure of the schist, and hence in general position it is perpendicular to the position of the tubes. Associated with it, in the green schist, is a noticeable amount of bright pyrite in fine cubes.

In the interiors of the rounded masses also can be seen irregular deposits of calcite. All this calcite is coarsely crystalline and firm, with hardness rather above the normal.

The interest which attaches to this rock centers in these tubular passages that converge from the outer surfaces of the rounded masses, and penetrate the latter to the depth of an inch, more or less. There is no exception; they are all marked with the same structure. The rounded masses are undistinguishable as rocks, from the rock about Ely. It has been supposed that such accumulations were agglomeratic, *i. e.*, that the rounded masses were of the nature of bombs thrown from volcanic vents, falling in an adjacent or surrounding ocean. It has been supposed that the light green country rock, in the midst of which this structure appears, is the result of oceanic solution and levigation on volcanic ejectamenta. Such ash and cinder when brought into contact with hot, or tepid, or even with cold, oceanic waters would easily be reduced to a non-differentiated pulp, from which some of the alkaline ingredients, being more soluble, would be removed, leaving the residue somewhat more siliceous. Upon consolidation a rock something like the greenstone seen at Ely might result.

On the other hand, as already stated, it is claimed by microscopists who have inspected such greenstones, that they are "altered eruptives," and that dynamic metamorphism has been the process that has effected their reduction to this condition.

It seems, however, that these peripheral tubes show that these rounded masses were suddenly immersed in an element which differed in temperature and pressure from that to which they had

been accustomed. They show that this rock was not a congealed plutonic mass, for such a mass could not acquire an amygdaloidal structure, except when it becomes volcanic. It is only when there is a sudden release of surrounding pressure that the confined gases of igneous rocks gain relief from their confinement, or that some of the confined substances manifest their volatility, forming scoriæ and amygdaloids. Was the element into which these were ejected, and which caused the rapid escape of gases, and then their rapid solidification, simply atmospheric air or was it oceanic water? If it had been atmospheric air then the surrounding rock, viz., the whole of the greenstone of the region was also ejected simply into atmospheric air and solidified under simply atmospheric conditions. Not having been since submerged, at least not having been since rewrought, it would have in that case to show not only many evidences of perfect igneous or "diabasic" structure, but it would have to exhibit about the same variations—barring the effect of greater time—as to stratification, texture, composition, etc., as can be seen in volcanic rocks of recent or Tertiary time. It could hardly shade off into the evidently sedimentary rock, having very nearly the same aggregate composition, seen but a short distance further north along the shore of Long lake, and it could hardly constitute a belt from 5 to 10 or 15 miles in width, lying always in the same stratigraphic position in the Archæan, and running, in accord with the strike of the rest of the Archæan, as well as substantially with that of the Taconic (which admittedly are governed by continental increments as the oceanic areas receded) for a distance of one hundred and fifty miles.

If on the other hand these bombs, torn from some portion of the already hardened super-crust by the loosening action of volcanoes, were hurled first into the air and fell into the ocean, all the structural, as well as all the microscopic characters which have been mentioned, might have been the result. The formation in which they are found would be amenable, as it is, to the geographic distribution and stratigraphic position which all oceanic formations are found to possess. They would have been buried along with other finer volcanic ash and cinder in the waters of a hot or tepid ocean. Such waters would rapidly destroy the characters of the usual minerals found in volcanic ejections. There would result secondary minerals, such as chlorite, sericite,

saussurite, leucoxene, serpentine, hornblende, etc., and these would, in some places be consolidated into rock which would possess many of the characters of an altered igneous rock, but would manifest more or less evidently the stamp of the ocean. There would be occasional foreign ingredients, particularly rounded quartz grains, and there would be in many places a fine intermixture of chemically precipitated silica, or perhaps of chemically precipitated oxide of iron, the last two uniting to form the well known jasperoid hematites. Again there would have to be many places, as there are, where the resultant rock would be very fine-grained, the ejecta having been totally disintegrated and reduced to a pulp or volcanic mud. When this accumulation was rapid there could be but little opportunity for the formation of characteristic sedimentary structures, but when it was slow the most evident sedimentary banding would result. There would be many places where the non-stratified would gradually acquire a stratified structure.

If we attempt therefore to effect such a compromise between the opposing disputants as the facts seem to warrant, we have to allow that the stratigraphist has a show of reason in insisting that oceanic structures permeate these greenstones, although the sedimentary banding is sometimes wholly wanting over large areas. We also have to allow that the nature, in general, of the minerals contained in these rocks is such as only igneous agencies can explain. In other words we must grant the chief contention of each party. The source of the rocks was igneous, but their structure is aqueous.

The recognition of this joint agency of oceanic water and igneous action in the production of these ambiguous rocks relieves the physical geologist of some rather severe strains of imagination as well as of dynamic laws to which, without such recognition he is compelled to resort. For instance, he has not to conjure up some hypothetical force through which he can explain, if he adhere to their sedimentary origin, the conversion of these "sediments" into a rock quite unlike ordinary sediments, and the absence of the usual structural characters. He has not to assume if he adhere to their igneous origin a semi-metamorphosed condition or any chemical change capable of converting a vast thickness of rock, situated at great depths in the crust, from a siliceous to a semi-basic character, nor *vice versa*. It has been gravely asserted by some extreme advocates of "alteration" that the

rocks of the crust may undergo and have actually experienced, such profound changes in average chemical composition that their original minerals may be entirely lost. Sometimes there is hypothecated a "silicification," and sometimes a desilication. The most basic rocks have been viewed, in some of these critical epochs of mythical metamorphism, as converted, by a substitution of "secondary silica" for the typical minerals of the supposed original basic eruptive rock, to a quartzyte, or to a quartz dioryte. Gabbros have been imagined converted to quartz syenites, and the details of the process of such transition *have been ingeniously imagined and illustrated.* Quartz, the most insoluble of the rock-making minerals, has been supposed to have been conveyed into the minutest interstices of these rocks to the depth of hundreds or thousands of feet, there taking the places of some of the original minerals which, by a reverse but no more mythical chemical transformation, were removed by the same waters, or at least by the same process. Again the geologist has not to resort to "dynamic metamorphism" by which to account for the shattered and partly disintegrated or degraded condition of the minerals of the greenstones. It is at best only a misuse of the term *metamorphism* to apply it to such a change, and it may be considered questionable whether the cause which dynamic metamorphism invokes would not produce a directly opposite effect. It is usually supposed that pressure and crushing and shearing develop heat, and thus tend toward the building up of the crystalline outlines and the strengthening of the chemical bonds, in the minerals affected. It appears to some geologists not only a misnomer, but a mistaken apprehension of the effect of dynamic forces to attribute such features to pressure and shearing and plication, and to call it "metamorphism." Such outre hypotheses can be shaken off the mantle of the speculative physical geologist, if he allow the building up of these rocks, as above suggested, through the cooperating, simultaneous action of oceanic waters and volcanic eruption.

A NEW SPECIES OF LARIX FROM THE INTER-GLACIAL OF MANITOBA.

By D. P. Penhallow, F. R. S. C., F. R. M. S., McGill University, Montreal.

Two specimens of fossil wood were recently received from Manitoba, the one from Mr. G. Elliott, of Guelph, Ontario, the other from Mr. J. B. Tyrrell, of the Geological Survey. The first was admirably preserved, and upon boiling with carbonate of

soda was readily cut by a microtome. The structure was found to be almost wholly intact and the effects of compression slight, so that there was no difficulty in determining its characteristics. The second was more fully impregnated with silica, so that somewhat prolonged treatment with carbonate of soda was necessary. Even then, there were localized siliceous bodies which offered some obstruction to the action of the knife. The structure was found to be fairly well preserved, and there was little change resulting from compression and distortion. The most marked general change in this, as in the first, was in the very strong development of striation on the cell walls. Little difficulty was experienced in determining the various structural characteristics, though there were numerous localized areas of decay and siliceous deposit where the structure had pretty completely disappeared. This was notably the case in the medullary rays, which, upon exposure in tangential section often showed complete obliteration of structure, indicating that the progress of alteration first proceeded along the course of these structures, while it was also noticed that fungus hyphæ penetrated first into the tracheids, following the course of their longitudinal or major axes, thence spreading laterally through the bordered pits.

The specimen received from Mr. Elliott was obtained by Mr. R. Brown when digging a well in Section 23, Township 3, Range 11, Manitoba. He recovered it from a depth of twenty-eight feet. In a letter from Mr. Elliott, he informs me that the surface soil was of about the usual depth of three feet of black, vegetable mould, beneath which, light blue lacustrine clay extended to where the wood was found. From data kindly supplied by Mr. Tyrrell the locality appears to be about three miles northeast of Pilot Mound, about seventy miles west of the Red river, and seventeen miles from the international boundary line. It is at an elevation of about 1,550 feet above sea level, and from 600-800 feet above the general level of the Red River valley on the Pembina mountains or second prairie steppe. The formation in that vicinity is level and apparently alluvial. As, from the information at hand, it seems likely that the boulder clays were not reached, the formation is probably to be regarded as post-glacial.

The specimen sent by Mr. Tyrrell was obtained from a well at Churchbridge, on the line of the Manitoba and Northwestern railway at a depth of two hundred feet. From the information so

far obtained, Mr. Tyrrell is inclined to regard the horizon as probably interglacial, to which it will be referred for the present. Mr. Tyrrell further expresses the opinion that the post-glacial deposits of Township 3, near Pilot Mound, may be the interglacial deposits of Churchbridge farther north, the glacier in its latest advance not having reached to the former place.

Microscopical examination shows that the two specimens are identical. They are, therefore, referred to the same species. Comparison with existing species of Larix show that it possesses characters approaching both *L. occidentalis* and *L. americana*, while in other respects it is quite distinct from both. It appears to be about midway between the two. It has, therefore, seemed expedient to distinguish it by a separate specific name, for which, as indicating the principal locality, I would propose *L. churchbridgensis*.

In the following description I have adopted certain standards which will also be employed in future descriptions by me. They are as follows:

The size of cells is the whole width from one primary cell wall to its opposite. The thickness of a wall is the distance from the center of the primary cell wall to the cell cavity, or one-half the total thickness. The pits of the medullary ray as exposed in radial section, are determined for the area of each wood cell—autumn or spring—covered by the medullary ray cell. The hight of the large medullary rays in tangential section, is ascertained by counting from each end towards the center, until the *first pair* of cells is reached. All others are included in the *central group*. The rays are described as unequal when the extension on one side of the central group is longer or shorter than on the other side. The thickness of the walls in medullary rays, is the whole width. The upper, lower and side walls of a medullary ray are those which would occupy the same relative positions, assuming the specimen to be placed vertically and the observer to look radially outward or inward.

Larix churchbridgensis, n. sp.

Transverse. Growth rings narrow. No very obvious demarcation between the spring and autumn woods, transition gradual; the spring wood at least equal to or twice the autumn wood. Wood cells disposed in radial rows. The autumn cells 14.4x24

μ broad, the walls 3.6 μ thick. Spring cells 24 μ square, the walls 2.4 μ thick.

Resin passages prominent, chiefly in the middle of the autumn wood, 21 μ to 100 μ broad; interior cells often conspicuous.

Radial. Medullary rays. Cells equal in length to three or more wood cells. Terminations square or very obtuse; septa with simple or bordered pits. Upper and lower walls strongly pitted—pits simple. Side walls with broadly oval pits, in the autumn wood 1-4 for each wood cell, in the spring wood 2-5 for each wood cell. Cells 19.2 μ broad, walls 4.8 μ thick.

Bordered pits. In autumn wood cells, obscure, remote. Outer ring 12 μ, inner ring 3.6 μ broad. In the spring cells, contiguous and somewhat flattened, or remote, distant 4.8 μ to 24 in. in one row. Outer ring 12 in. to 16.8 in., inner ring 3.6 in. to 4.8 μ broad.

Terminations of the tracheids obtuse or acute.

Tangential. Medullary rays. Large rays upwards of twenty-four cells high plus the central group. Few, chiefly equal, rarely and slightly unequal. The small rays one cell broad, 1 to 13 cells high. Markings on the tangential walls of tracheids, none. Terminations of the trachieds acuminate, strongly overlapping.

GOLD IN PLACERS.

HERBERT R. WOOD, Missoula, Mont.

Gold may occur in placers in different ways, and these placers may be of very different character.

1. Along creek beds and in bars and banks of rivers; the gold usually in such a case having been carried a long distance.

2. In sloping banks and beds along the bases and flanks of mountains usually not far removed from the source of the gold.

3. In bars or plateau-like beds extending far out into valleys, frequently terminating abruptly in a cliff-like fashion but having their sources in the mountain ranges.

4. In mountain ranges placer beds occur, caused by the decomposition of veins, and the placer beds occurring on or near the side of these veins.

5. Along the flanks and at the mouths of gulches, placer beds frequently occur, having been washed down and deposited through the same denuding forces which formed the gulch.

Notes 1—In case of No. 1, rivers frequently cut gold bearing veins in their courses. This seems to be the only plausible explanation of the occurrence of gold beds on Snake river, Idaho; these beds in which the gold is found on the surface are far removed (in some cases, forty or fifty miles) from their sources.

No. 3.—These gravels have been no doubt rearranged by action of water, presumably by a lake.

No. 4.—The vein, owing to decomposition and disintegration may be converted into soil or quartz pebbles to considerable depth, the quartz pebbles frequently containing native gold, showing a slight attrition.

The method of arrangement of gold in placers, depends on various conditions which can hardly be considered sufficient basis for classification. Thus its comparative depth in the gravels, its tolerably uniform dissemination, or local occurrence, its physical characters, etc., depend on such forces as gravitation, distance from source, denuding forces, time of denudation and deposition; and these different methods of occurrence may be found indeed in any of the varieties of placer beds. As regards the nature of the force which brings down the material from the mountains, and causes the rounding of the rock fragments, it may be of a varied character and admit of classification.

1. *The melting of snows* and rainfall, producing spring freshets and streams.

2. *Glacial action.* This must have been a very common agency from the evidence obtained.

3. *Gravitation.* A natural settling down of rock fragments loosened by chemical disintegration to a lower level. This is largely aided by the percolation of waters.

With regard to this latter method of forming placer beds, Hayden, in his report on Geology of Colorado, refers to the force of gravitation as not unusual in the formation of gravel beds and banks along the bases and flanks of mountains. The character and great extent of many gravel beds, show very plainly that the denuding agencies must have been very active at one time in the recent history of the hills. This seems to be best explained by the action of glaciers which during the glacial period must have covered the mountains and caused during their recession in a more genial climate the immense beds of detritus which the rivers and streams flowing from them piled up in the valleys below.

In Montana, of which country this paper more particularly treats, gold occurs *in situ*.

1. Native in quartz veins in granite, slate, and quartzite.

2. In chemical combination with iron pyrites, also copper pyrites. These veins occur in slates and granites, the accompanying gangstone usually being quartz.

3. In brown iron ores the result of weathering and chemical decomposition of iron pyrites, which weathering or oxidizing influence may extend to considerable depth in the vein owing to the action of percolating surface waters, or be limited to a few feet. The gold in this instance is free, but in a very fine flour-like condition. Such veins where the ordinary action has extended to a great depth, usually occur in slates or a rock which admits of the ready percolation of water. This changed condition is seen in all veins holding iron and copper sulphides.

4. Gold occurs in more or less quantity in all veins in Montana. In pure galena a small trace is obtained, as well as in copper sulphide.

5. In a very few instances a small percentage of gold has been found in quartzite dikes. The quantity is rarely sufficient to warrant working.

As to its physical properties the gold may be a light yellow or a dark yellow, holding a variable proportion of silver. It may occur,

1. In large nuggets.
2. Moderately coarse—angular.
3. Moderately coarse—much worn.
4. In grains and scales (fine).
5. Flour-like condition.

Some of these nuggets have been of considerable size, one obtained at St. Louis gulch, weighing nearly 21 ounces, while those weighing two or three ounces and more are of frequent occurrence.

NOTES—

1. A probable explanation will be found farther on.

2. When angular, the gold has not been subjected to much attrition and not carried far from its source.

3. Carried considerable distance and subject to much attrition.

4. A very common form for gold to assume in placer beds. This is its most common condition in the vein material, thin leaves and scales.

5. This flour-like gold results chiefly from the oxidation of iron pyrites, the gold becoming freed in a very fine condition in the brown iron ore which results from the chemical change.

Briefly speaking the physical features of western Montana are similar to many mountainous countries. It is characterized by a series of more or less parallel ranges, having a general northwesterly and southeasterly direction with intervening valleys. The mountains having been formed by upheaval, lateral pressure and subsequent denudation. In most of the ranges the central core of granite has been exposed with highly tilted slates, limestones cut by porphyritic and quartzite dikes abutting it.

At mount Ogden, a mountain of granite (a true granite) which is intersected, near a contact with a bed of quartzite, by a series of narrow quartz veins holding auriferous iron pyrites and free gold—the placer beds are situated along the base of the mountains, a direct incline at an average slope of 35°, about a mile distant from the source. The gold can be found, however, along the entire slope intervening. This granite is very much decomposed to a depth of twenty to twenty-five feet, so that in developing these veins no blasting was done to that depth. The disintegration has taken place in the granite owing to change in feldspars and the oxidation of iron pyrites which is thickly scattered through it, assisted by percolating waters and action of frost.

The easy removal of this decomposed rock by melting snows, assisted by the natural force of gravitation is obvious.

The manner of the removal of the gold from the veins is, I imagine, that suggested by Wurtz, the formation of persulphate of iron in which gold is slightly soluble. This may act as a carrier, a deposition of metallic gold resulting as a nugget; or the gold is worn from the rock holding it, and carried by the water into the gravels.

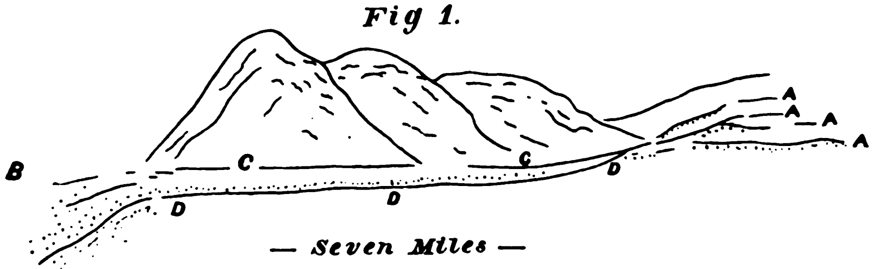
Placer beds vary according to the class to which they may belong as regards the nature of the pebbles and boulders, or the presence, absence, scarcity or abundance of them, the presence of black magnetic sands, the depth of the bed and the arrangement of the gravels and boulders in them.

To give an idea of the nature of a placer bed the following account of St. Louis gulch, twenty-five miles east of Helena, as illustrating No. 5 is given. At the mouth of the gulch which has a general course north and south and from which a creek flows

into the Missouri, the detritus and wash from the gulch extends out in a broad fan-shaped sloping terrace for two or three miles. The gold is disseminated to a greater or less extent throughout the whole of this bed, but only in workable quantities in certain localities noticeable at the immediate entrance to the gulch. As we proceed up the gulch the gold bearing strata gradually sink to a depth of 60 feet or more, to which shafts have been sunk to the gold bearing zone. Towards the head of the gulch which is six or seven miles in length the gold belt rises till it merges on the surface and at the extreme head of the gulch splits into finger-like streams which have been traced to the veins *in situ* from which the gold came.

Fig. 1 represents a longitudinal section of the gulch, in which the dots show the deposition of the gold in the detritus gravels from the mountains. A A A are veins, B the exit and fan-shaped

Fig 1.



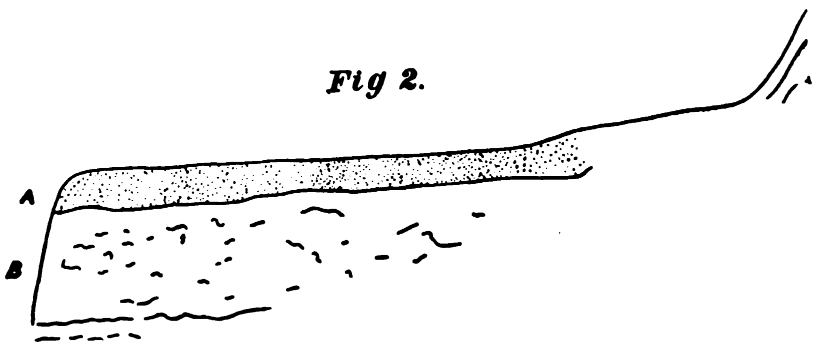
— *Seven Miles* —

bed of gravels. C the surface line of detritus. D the line of deposition of gold. The veins consist of one very large vein of nearly pure iron pyrites, associated with some quartz as a gangue. It is about forty feet in width, and has been mined to a depth of 90 feet, to which depth the pyrites was decomposed into oxides of iron.

In the vicinity of this vein are numerous small veins of a few inches in width up to which the gold streaks lead in the gravels. The country rock is an eruptive trap-like rock. At the head of the gulch near the veins the large nuggets were obtained. This is easily explained by the great weight of these large nuggets, which are deposited first as the detritus was laid down by the running water. The veins vary in their direction, one vein penetrating the east side of the gulch for 1,500 feet, and being only two or three inches in width, assaying $2 to the ton. As to

the origin of this gulch it may have been produced by glacial action or by the denudation of running waters from freshets and melted snows. The richest localities in this gulch were the outer points and margins of the slopes at the termini of the finger-like streams. This is easily explained also by the deposition of the coarser gold at the head of the gulch. If the gold continues to stream down and follow chosen finger-like paths, in the vicinity of the veins in such a placer, the denudation presumably being slow, the occurrence of nuggets of such an unusual size as 20 ounces might be explained on the theory that persulphate of iron holding an appreciable amount of gold in solution deposited its gold in a certain spot, a large mass of gold thus gradually accruing. This

Fig 2.



theory is given in Le Conte's text book of geology, in reference to the auriferous gravels of California.

As illustrating No. 3, in the Flint Creek valley in western Montana, Deer Lodge county, near Stone, placer beds occur in the form of long bars or level plateaus which extend for several miles north from the mountain ranges. They terminate abruptly in a cliff-like margin.

The gold bed A, Fig. 2, occupies the upper stratum of this plateau for several feet, and is sharply marked off from the lower gravels B. The gold stratum was evidently a later flow from the mountain, and has been rearranged and deposited by lake action. These plateaus have been the result of glacial action in this instance. Large and subangular boulders occur in the gravel beds, and scattered along the valley below.

As regards the character of the boulders, which make up the placer bed, they may consist of all kinds of rock, but more

usually granite, slates and quartzite accompanied by iron-stained quartz, boulders and pebbles, presumably from the veins themselves, frequently black magnetic sands, and more or less fine alluvials. These beds attain great thickness, often resting on the bed rock which may be two or three hundred feet below the surface.

Placer beds may exhibit a stratified arrangement of the gravels, boulders and sands, the gold confining itself to particular horizons. The proportion of fine detrital matter and clays, in a placer claim varies very much. There may be a good deal of intermingled dirt and sands, and frequently the bed may consist almost wholly of pebbles and boulders. In this latter instance, I believe the gold gradually sinks down in the bed, when unobstructed by clays and subject to continual action of percolating waters, to a lower level. The arrangement of the gold in streaks in the bed, or its uniform distribution depends less perhaps on the proximity of the bed to the source, than to the force of distribution and denudation; beds several miles removed from their source frequently having the gold arranged in streaks, by water action.

[*Notes on Palæozoic Crustaceæ No. 2.*]*

ON THE NORTH AMERICAN SPECIES OF THE GENUS AGNOSTUS.

By A. W. Vogdes, Fort Canby, Wash.

HISTORICAL SKETCH OF THE GENUS AGNOSTUS.

The earliest known species of this genus was described and figured by Bromell in 1729, Lithographia Suecana, Actis Liter., Sueciæ, Upsal, vol. 2, p. 527, under the name of *Vermiculi vagipennes*. The author mistakes the fossil for an insect and figures *Agnostus pisiformis* from the Olenus schist of Andrarum, Sweden. For a period of almost one hundred years this was the only representative of a genus, to which Brongniart gave the name of *Agnostus*, taking for its type *Agnostus pisiformis* from Linné's *Entomolithus pisiformis*, Syst. Nat. Ed. XII, p. 160.

Dalman uses the same species for the type of his new genus *Battus* in 1826, Palæaden p. 257.

In the year 1828, Dalman, Vetensk, Akad, Årsber, p. 136, described a new species from Gothland under the name of *Battus lævigatus*, and a new variety from Andrarum, as *Battus pisiformis* var. *spiniger*. The next contribution to our knowledge of this genus was made by Beyrich in 1845, Ueber Böhm Trilobiten, p. 44. The author adds two new species to the list from the Paradoxides zone of Bohemia, under the

*No. 1 of these notes is published in Trans. St. Louis Acad. Sci., Vol. V, 1891.

names of *Battus nudus* and *B. integer.* The discovery of an entire specimen by this author removed the doubts regarding the affinities of these fossils with the order Trilobita.

The investigations made by M'Coy in 1846, Syn. Silurian Fossils of Ireland, p. 56, added the new genus *Trinodus* and one new species, *T. agnostiformis.* The non-adoption by palæontologists of *Trinodus*, and the imperfect illustration of this species have caused several identical forms to be classed under new names such as *Agnostus convexus* Salt. *A. trinodus* Salt. and *A. tardus* Salt., Brit. Pal. Foss. 1851, p. 141 (not Barrande's species). The species ranges high up in the geologic column as it approaches its extinction, in the zone with the genus *Asaphus* and *Trinucleus.*

Barrande described in his Preliminary work on the Silurian System of Bohemia, 1846, pp. 14 and 35, nine new species under this genus; which he reduces to six in his final great work on the Bohemian trilobites. Etage C with *Paradoxides bohemicus* contains—*Agnostus integer* Beyr., *A. granulatus* Barr., *A. nudus* Beyr., *A. bibullatus* Barr. and *A. rex* Barr. Etage D with *Asaphus nobilis* contains *Agnostus tardus* Barr.

Corda, Prodrom 1847, reclassifies the genus into seven new genera and 29 species. All the genera and species have been referred to well known Bohemian species and genera.

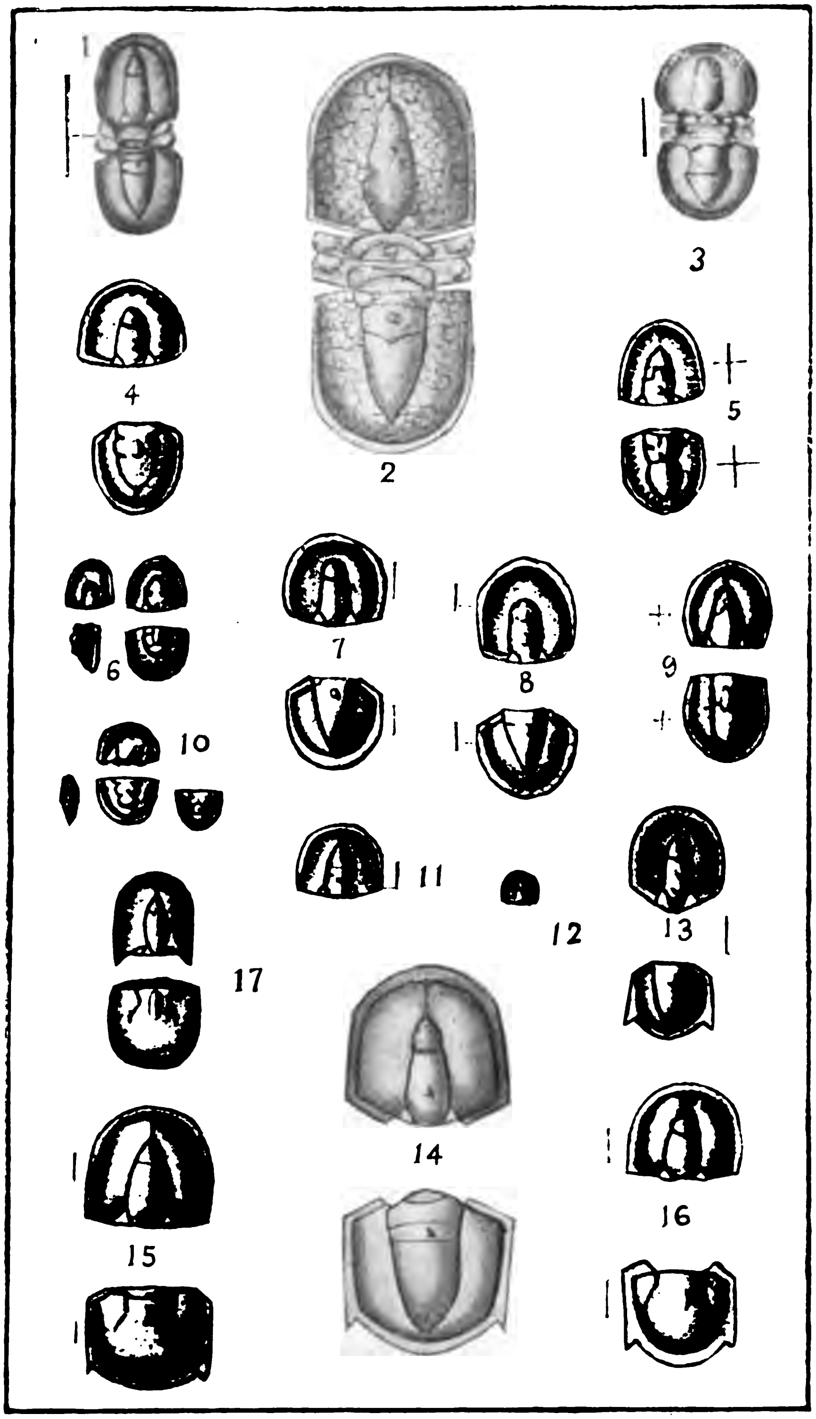
In the Mem. Geol. Survey, vol. 2, part 1, p. 351, pl. 8, Salter & Phillips reproduce under the name of *Agnostus trinodus* the Irish species which M'Coy described as *Trinodus agnostiformis.* The authors also describe a variety of this species as *convexus.*

1851—Angelin describes and figures 12 species from Sweden, Palæont. Scand., p. 5, pl. 6. Regio A (Olenus zone). *Agnostus pisiformis* Linné, *A. laevigatus* Dalm., *A. reticulatus* Ang., Regio B (Paradoxides forchhammeri zone), *Agnostus planicauda* Ang., *A. exsculptus* Ang., *A. punctuosus* Ang., *A. aculeatus* Ang., *A. brevifrons* Ang., *A. glandiformis* Ang., *A. bituberculatus* Ang., Regio C (Asaphus zone), *Agnostus lentiformis* Ang., Regio D., *Agnostus glabratus* Ang.

The first North American contribution to *Agnostus* was made by Billings in 1860, Canadian Nat., vol. 5, p. 302, in which he describes from the so-called Quebec group, three new species, *Agnostus americanus*, *A. orion* and *A. canadensis.* These species are republished in Palæozoic Fossils of Canada, vol. 1, 1865, p. 395. *Agnostus americanus* is of the type Longifrontes, congeneric with *A. trisectus* Salt. which occurs at Andrarum with *Peltura* and *Sphærophthalmus.* *A. orion* differs from *A. pisiformis* by having the glabella proportionally shorter. The same name was used by Barrande in 1846 for a species of the genus.

1860—Eichwald, Lethea Rossica, vol. 1, p. 1351. The author describes four species, two of which are for the first time illustrated—*Agnostus paradoxus* Eichw. and *A. nodiger*, n. sp. Eichwald refers *A. beckii* to *A. exsculptus* Ang. The two new species are from the Asaphus zone.

1863 -An important contribution to American palæontology was published during this year by James Hall; entitled Preliminary notice of the fauna of the Potsdam Sandstone, 16th Report N. Y. State Cab. Nat.



NORTH AMERICAN SPECIES OF AGNOSTUS.

Hist. The memoir describes the fossils of the Dikelocephalus zone of Wisconsin. In this work we have illustrations and descriptions of *Agnostus josepha*, *A. parilis* and *A. disparilis*. The first species approaches *A. cyclopyge* Tull. of the Olenus zone of Sweden. The second is of the type Lævigati of which *A. lævigatus* Dalm. is its nearest congeneric form. Dr. Shumard described in the Am. Jour. Sci., vol. 32, 1861, p. 218, *Agnostus coloradensis* from Burnet county, Texas. This species is of the type *A. neron* H. & W.

1864—Salter in the Mem. Geol. Survey, Decade XI, describes five new species of the genus as follows: *Agnostus princeps* also vars. *ornatus* and *rudis* (Olenus zone). (This species is of the type *A. atavus*, *gibbus*, *punctuosus*, *americanus*), *Agnostus maccoyii*, Upper Llandeilo Flags, Wales, *A. limbatus*, Caradoc, *A. morea*, Lower Llandeilo, *A. trinodus*, syn. of *A. agnostiformis* M'Coy, *A. trisectus*, Upper Lingula. (This species occurs at Andrarum with *Peltura* and *Sphærophthalmus*).

1865—Billings in the Palæozoic Fossils of Canada, vol. 1, redescribes *A. americanus*, *A. orion* and *A. canadensis*. The author adds two new species to the list from the so-called Quebec group of Newfoundland, *Agnostus galba*, and A. *fabicus*. The former species differs but slightly from *A. tardus* Barr., Etage D, in Bohemia. The latter approaches *A. lentiformis* Ang., Regio C, of Sweden.

1866—Schmidt describes a new species in the Bull. Acad. Sci., St. Petersb., vol. 30, 1866, p. 505, fig. 45, *Agnostus cyckanowskii*.

1866—Linnarsson describes a new species in Om de Siluriska bildningarne i Mellersta Westergötland; *Agnostus affinis* from the zone with *Paradoxides tessini*.

1867—Belt in the Geol. Mag., vol. 4, p. 294, describes *Agnostus nodosus* and *A. pisiformis* var. *obesus*, from the "Upper Cambrian" of Wales. Tullberg remarks that *A. nodosus* Belt is probably identical with *A. reticulatus* Ang. The author illustrates a broad and narrow form of *A. pisiformis* var. *obesus*. In vol. 5, 1868, of the same magazine, the author describes *Agnostus obtusus* from the Upper Dolgelly and *A. barlowii* from the Tremadoc.

1868—Barrande describes *Agnostus bavaricus*, in Fauna Silurienne des environs de Hoff en Baviere, p. 32, figs. 46-47.

1869—Linnarsson, Om Vestergötland Camb. & Sil. aflagringar. The author describes 8 species of *Agnostus* including the following new species, *A. gibbus*, *A. parvifrons*, *A. sidenbladhi*, and *A. fallax*. The first two species occur with *Paradoxides tessini* at Andrarum. *Agnostus sidenbladhi* ranges higher up in the Ceratopyge chalk.

Sjogren in Om nagra forsteningar i Oland Kambriska lager 1871, describes *Agnostus regius* from the zone with *Paradoxides olandicus*.

1871—Hicks in the Quart. Jour. Geol. Soc., vol. 27, 1871, p. 400, describes a new species, *Agnostus cambriensis*.

1872—Meek in the sixth Report U. S. Geol. Sur. Territories, p. 664, gives the name of *Agnostus maladensis* to a species from Malade City, Utah; and that of *Agnostus bidens* to one from Gallatin City, Montana.

1872—Hicks in the Quart. Jour. Geol. Soc., vol. 28, 1872, p. 174, de-

scribes five species, illustrating a new one under the name of *Agnostus eskriggei* from near Dolgelly, Wales. This article also contains descriptions of *Agnostus davidis* Salt., *A scutalis* Salt., *A. scaraeoides* Salt. and *A. barrandei* Salt.

1872—Ford illustrates an imperfect trilobite under the name of *Agnostus nobilis* in the Amer. Jour. Sci., vol. 3, 1872, p. 421. This species is from the Olenellus zone near Troy, New York, and may prove to be a species of the genus *Microdiscus*, which occurs in the same locality.

1872—Barrande describes three new species from Etage D, in the Supplement Syst. Sil. Bohm., vol. 1, 1872: *Agnostus caducus*, *A. perrugatus* and *A. similaris*.

1876—Kayser, Beiträge zur. Geol. & Palæont. der Argentinischen Republik, p. 5. The author describes *Agnostus tilcuryensis* from the Olenus zone.

1877—White in his Preliminary Report for 1874, also in the final Report U. S. Geol. Sur., west 100th Mer., vol. 4, 1877, describes *Agnostus interstrictus* from Antelope Springs, Utah. This species is related to *A. integer* Beyr.

Hall & Whitfield in U. S. Geol. Sur. 40th Par., vol. 4, 1877, describe four new species from the Dikelocephalus zone of Nevada: *Agnostus communis*, *A. neon*, *A. prolongus*, *A. tumidosus*.

1878—Hartt, in Dawson's Acadian Geology, 2d Edition, describes *A. acadicus* and *A. similis*; the latter species is now included as a synonym of *A. acadicus*.

1878—Brögger, Om Paradoxideskifrene ved Krekling, describes 14 species including the following new forms, *Agnostus gibbus* var. *hybrida* *A. kjerulfi*, *A. nathorsti*, *A. incertus*, *A. parifrons var. mammilata*, also var. *nepos*, *A. nudus var. marginatas*, *A. punctuosus* var. *affinis* and *A. truncatus*. All these species occur in the Paradoxides zone.

1880—Tullberg, in his excellent monograph on the Agnostus species in the Cambrian formation at Andrarum, illustrates and describes 28 species of this genus with the following new species: Group Longifrons—*Agnostus fissus* Lund, MSS., *A. atavus*, *A. intermedius*, *A. elegans*, *A. lundgreni*, *A. cyclopyge*, *A. pusillus*. Group Lævigati—*A. cicer*. Group Limbati—*A. quadratus*.

Dames in Richthofin's China, vol. 4, p. 27, pl. 2, describes *Agnostus chinensis* from the Olenus zone.

1882—Holm, in Kongl. Svenska vet. Akad. Handl., vol. 6, No. 9, describes *A. torquisti*.

1884—Walcott in Palæont. Eureka Dist. describes six species including two new species: *Agnostus seclusus* and *A. richmondensis*. The first species is of the type *A. parvifrons* Linrs. and the second of *A. nathorsti* Brögger.

1885—Matthew in the Trans. Roy. Soc. Canada, vol. 3, describes 10 species from the Paradoxides zone of St. John: *Agnostus regulus*, *A. partibus*, *A. cir*, also var *concinnus*, *A. acadicus* Hartt, var. *declivis*, *A. tessella*, *A. umbo*, *A. obtusilobus* and *A. acutilobus*.

1889—Walcott describes in the Proc. Natl. Mus. vol. 12, 1889, the only known American Olenellus zone Agnostus, under the name of *A. desideratus*, from Salem, New York. This species is illustrated in the 10th Report U. S. Geol. Survey, p. 630, pl. 80, fig. 5.

RECAPITULATION *

From the Olenellus zone, *Agnostus nobilis* Ford, *A. desideratus* Walcott, *A. fallax* Linrs	3
From the Paradoxides zone	44
From the Olenus zone	6
From the Dikelocephalus zone	19
From the Asaphus zone	18
	90

AGNOSTUS, Brongniart, 1822.

Diagnosis.—The general form of the body of the Agnosti is elongated elliptical, the surface convex. The head presents the same structure as that part in other trilobites, with the exception of eyes and facial suture, which are wanting in this genus. The glabella determined by the dorsal grooves, never extends to the anterior contour; it is always prominent by its relief; its form varies with the species. The typical form has a glabella divided into a small frontal lobe, and a larger posterior lobe; the basal lobes forming a third part. The frontal lobe is usually subtriangular having a groove in front (*A. pisiformis*, plate IX, fig. 14). In the section Limbati, the glabella is broadly rounded in front, showing a great development as in *A. rex*, plate X, fig. 13. In the section Parvifrontes, the glabella has only a single lobe, as in *A. parvifrons*, plate X, fig. 12. In the typical glabella the posterior lobe exhibits an inclination to divide laterally, or in front, being marked by a medium ridge. The glabella is sometimes compressed on the sides by the basal lobes, but expands at this point again in its posterior projection, as in *A. gibbus*. The basal lobes are very short, so that in *A. gibbus*, they appear like a narrow band widening out on both sides of the head, forming two nodes, which are sometimes large and triangular, as in the section Fallaces. The basal lobes are divided in some species into two nodes on each side, as in *A. atavus*, but, they are generally very minute. The occipital groove and ring are more or less developed. The lateral lobes of the head form a concentric band with the contour; this is called by Barrande the *genal zone*. In the section Longifrontes, the cheeks in front of the glabella are divided by a furrow extending from the apex of the glabella to

*The varieties are omitted in this enumeration.

the limb. The surface of the genal zone is smooth in the section Limbati, but, in Longifrontes they show a tendency to striate or punctate. The limb around the head is always wider in front and narrowed towards the thorax. One can distinguish upon its surface an internal groove, and an external ridge forming the contour, sometimes the limb is extended into small points on each side, as in *A. josepha*. In the section Lævigati the limb becomes obsolete; in the section Limbati it is broad. The thorax has two segments in all the known species. The axis is usually well developed in width, whereas the pleuræ are often reduced; when the trilobation is distinct, as in *A. rex*, the thorax shows the same characteristic; when it is faint, as in *A. nudis*, the trilobation is also indistinct. The first segment is subdivided by a groove which gives to the pleuræ two bands more or less elevated, the anterior band being the larger; the second segment has the pleuræ on each side divided into bands of equal width; the points of each pleuræ are directed forward. The pygidium conforms to the head. In certain species, for example *A. bibullatus*, the pygidium is marked with dorsal grooves; but the head shows no trace of these grooves. In *A. rex* the axis of the pygidium reproduces that of the thorax. The lateral lobes form a concentric zone to the contour sometimes united, but often separated behind the axis. The limb surrounding the pygidium is sometimes extended into points. If the head has no border, that of the pygidium is augmented as in *A. nudis*. The typical axis occupies generally $\frac{2}{3}$ of the total length. In front of the axis is located a small triangular border (genou articulaire). The axis has three joints; the center lobe is usually the smallest, but attains the greatest hight; it carries typically on the medium line a node, which sometimes is extended backwards over the third joint (*A. nathorsti* and *A. aculeatus*), also extended into a spine in *A. gibbus*. In *A. rex* the middle joint on the axis is divided by a groove, into an upper and lower lobe. The anterior joint of the axis has an inclination to become separated into three lobes; the two side lobes are common. The last joint is heart-shaped. In *A. rex* the last joint is short and rounded; in *A. cyclopyge* it is large and rounded. Sometimes the axis is long, *A. fallax*. The side lobes when the axis is short unite behind it. In the typical species they are divided by a furrow, which often becomes obsolete. In *A. kjerulfi* and *A planicauda*

an elevated ridge extends from the spines of the pygidium to the axis.

In the section *Laevigati*, the dorsal grooves are limited on the head, only partly defining the glabella; they are also limited on the pygidium, especially in rear, as in *A. laevigatus* Dalm., plate x, fig 3. In the section Arthrorhachis the glabella is prominent, long and marked with small basal lobes; the axis of the pygidium is short, as in *Agnostus tardus* Barr.

PART 3. DESCRIPTION OF THE NORTH AMERICAN SPECIES.

The insignificant genus Agnostus surpasses in number of species all the other genera of the order Trilobita; in the primordial fauna we have a total number of ninety species, excluding the varieties. The species range from the Olenellus zone to the Lower Silurian. The zone with Paradoxides contains 44 species and several varieties; the Olenus is not so well represented; but, the genus outlived both these genera and extends into the Ceratopyge chalk (*A. sidenbladhi*) also in the Orthoceras zone (*A. lentiformis* &c). The genus dies out in the zone with Asaphus and Trinucleus (*A. trinodus* &c). In North America the genus is represented by twenty-eight species which may be arranged into the following zones and sections:

OLENELLUS ZONE.

AGNOSTUS NOBILIS Ford, 1872.

This is a doubtful species and may belong to the genus *Microdiscus*.

Section I. **PARVIFRONTES.**—The glabella is only partly developed in this section (*Agnostus brevifrons* Ang., plate x, fig. 12).

AGNOSTUS DESIDERATUS Walcott, 1890.

Plate x, fig. 7. Cf. *Agnostus prolongus* Hall.

Diagnosis. Head about as broad as long, broadly rounded in front, sides curving in slightly towards the posterior margin, which slopes obliquely inwards from the postero-lateral angles to the glabella. The glabella is less than ⅔ the length of the head. A narrow raised rim extends all around the margins, except across the base of the glabella, which is subcylindrical, narrow, with a small node on the posterior third of its medium line. Surface smooth. Locality, Salem, N. Y. This species is of the

type *A. parvifrons* Linrs. which appears with the genus *Paradoxides* in Norway. The pygidium of *A. prolongus* Hall, pl. x, fig. 10, has a similar form to the head of this species. The author illustrates only the head. An associated pygidium has a prominent axis bordered by a narrow convex space between it and the limb. The axis does not exhibit lateral, or transverse furrow. An elongated median tubercle is the only ornament.

PARADOXIDES ZONE.

Section II, **LONGIFRONTES**. This section is distinguished by its strongly projecting glabella and axis, which latter is generally moderately long. Crust smooth. The cheeks grooved. The crust on the cheeks and pygidium is provided with raised points. Limb generally narrow. The cheeks in front of the glabella and side lobes of the pygidium, behind the axis, divided by a groove. (*Agnostus punctuosus* Ang., pl. IX, fig. 2, also *A. pisiformis* pl. IX, fig. 14).

AGNOSTUS ACUTILOBUS Matthew, 1885. Plate IX, fig. 1.

Diagnosis.—Body elliptical, elongated. Head semi-elliptical. Dorsal furrow faint, marginal furrow and fold sharply defined. Glabella subconical, length ⅘ of that of the head. The glabella is divided into two lobes; the anterior lobe is ⅓ of the length and subtriangular, posterior lobe extends to the base of the head. It has an elongated ridge on the anterior half, with two faintly marked lateral furrows on the lateral edges of this lobe. The basal lobes are divided off by a sigmoid furrow and depressed below the level of the glabella. Occipital ring narrow. The cheeks are somewhat full especially in front and divided by a furrow, each cheek is seamed across by a faint furrow. Thorax of two segments; the first has five lobes, the second only three. Pygidium subelliptical. Axis is oblanceolate, nearly ⅓ as wide as the pygidium and its length is about ⅘ of that of the pygidium, narrowed in the anterior third, and crossed in that part by two transverse furrows; the included lobe bears an elongated tubercle; lateral lobes of the pygidium moderately elevated and united behind the axis. Surface smooth externally, but it is granulated on the inner surface of test.

Locality. St. John group, Porter's brook, St. Martin's.

The species differs in minor points from *A. gibbus* var. *hybridus* Brögger, especially in having an elongated ridge on the front of the posterior lobe of the glabella.

AGNOSTUS OBTUSILOBUS Matthew, 1885. Plate IX, fig. 3.

Cf. *A. scarœoides* Salter, 1872, from which it differs by a narrower glabella with a more obtuse front.

Diagnosis.—The head of this species is like that of *A. acutiloba* Matthew. The pygidium described under this name is subquadrate in form, wider behind than before, and has a pair of spines at the outer angles. The axis is nearly one-half as wide as the pygidium, about four-fifths of its length and projects forward beyond the side lobes; it is obtusely lanceolate, somewhat narrowed in the middle, and divided into three lobes, of which the posterior is a ½ longer than the length of the two anterior. The middle lobe is elevated in the middle, and bears an elongated tubercle on the axial line; there is also a faint tubercular elevation on the middle of the anterior lobe. The lateral lobes of the pygidium are somewhat narrowed in the middle of their length by the projecting sides of the axial lobe, and rapidly behind the pygidium, where they connect. The dorsal furrow is deeply impressed all around, and at the posterior angle is very close to the marginal furrow; this furrow is angled forward to the axial lobe and quadrately rounded at the posterior side of the pygidium.

Locality. St. John group, Porter's and Hanford brooks, St. Martin's.

AGNOSTUS TESSELLA Matthew, 1885. Plate IX, fig. 4.

Diagnosis.—Head semi-elliptical, higher in the middle and rear part. Dorsal furrow distinct on the posterior ⅘ of the glabella, faint on the other ⅕. Limb strongly elevated; the interior groove deep and strongly impressed. Glabella cylindro-conical, rounded in front, the width ⅓ of that of the head; the length five-sevenths. The frontal lobe of the glabella is depressed to the level of the cheeks, and almost obsolete; the posterior lobe is cylindrical, rounded behind, bounded in front by a straight, deep furrow, and bears a small tubercle ⅓ from the front. Basal lobes small. Thorax of two segments. The anterior segment bears five lobes of which the two lateral pairs are globose; the axis is transversely elongated, wider behind than before, and bears a minute tubercle at the axial line. The posterior segment is simi-

lar except the tubercle. The pygidium is semi-elliptical, somewhat wider than long, strongly elevated along the axis, truncated in front at the lateral thirds. The axis is cylindro-conical, width $\frac{1}{2}$ the pygidium, length $\frac{3}{4}$; it bears an elongated tubercle on the axial line at the anterior $\frac{1}{3}$; short furrows indent the sides of the axis, opposite the ends of this tubercle. The side lobes are narrow and divided at the extremity of the axis by a furrow, connecting the dorsal and marginal furrows.

Locality. St. John group, at Porter's brook, St. Martin's.

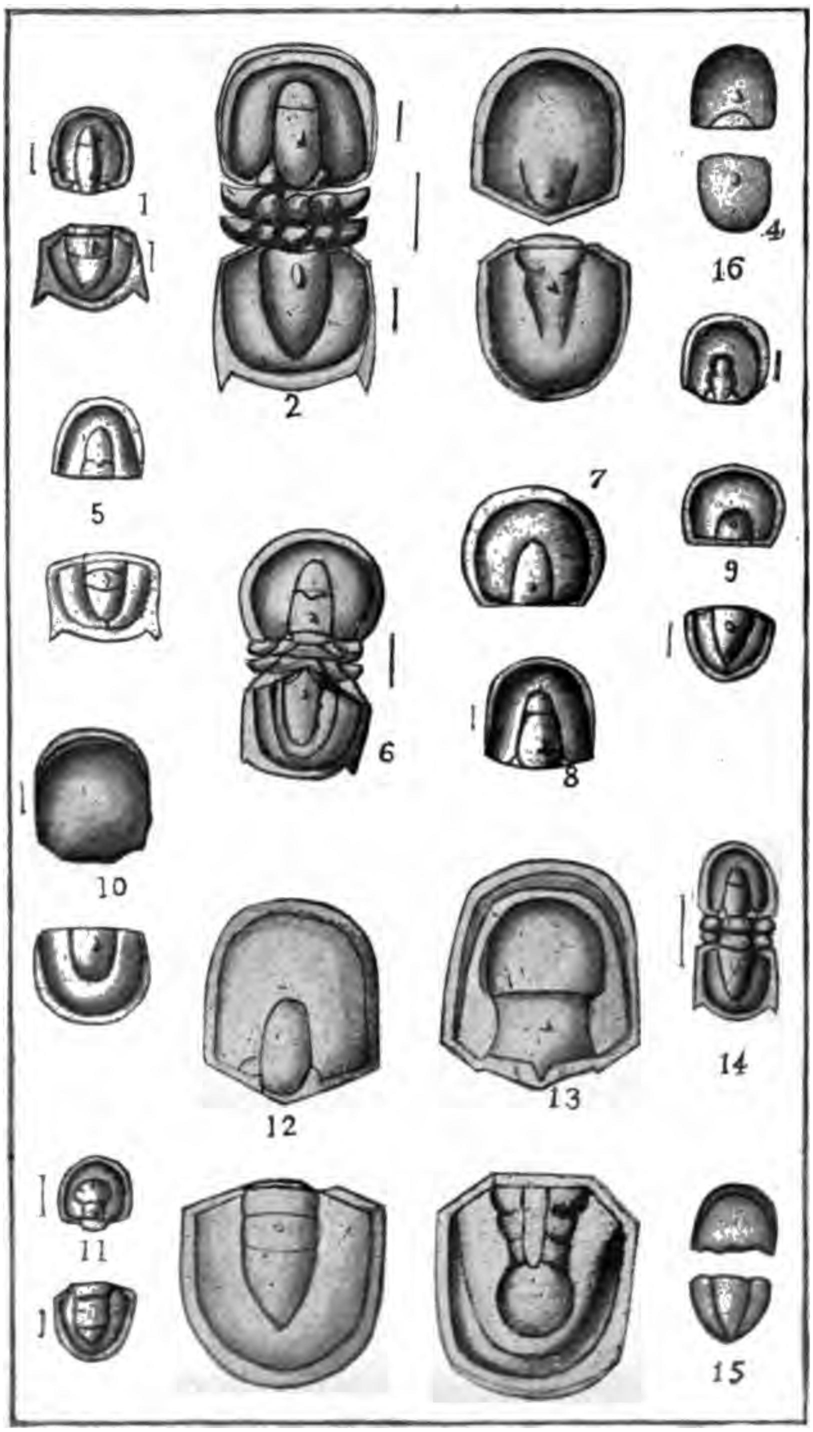
AGNOSTUS ACADICUS Hartt, 1878. Plate IX, fig. 7. Syn. *Agnostus similis* Hartt.

Diagnosis.—Head convex, depressed. Limb narrow, slightly elevated. Glabella slightly less than $\frac{3}{4}$ of the length of the head, long, elliptical, depressed convex, but more elevated than the other parts of the head; frontal lobe of the glabella, sub-circular and occupying about $\frac{1}{3}$ of the glabella; basal lobes small, but distinct. Cheeks of the same width throughout and united in front of the glabella; they are convex, more elevated along their inner margins, but sloping outwards roundly and evenly. The genal zone has a narrow, shallow, flat space or groove which follows the limb; on going posteriorly along the lateral margins it loses gradually its width towards the posterior angles of the head. Thorax unknown.

Pygidium similar to the head. The limb slightly raised, separated from the sides by a shallow but well marked groove running parallel to the margin. This groove widens at the point where it bends to go forward along the sides, in such a way as to encroach on the thin out of the limb; just before reaching the anterior margin it narrows itself from the inner side, so as to cause the side lobes to widen somewhat anteriorly. These are narrow, flattened, about $\frac{1}{3}$ as wide as the axis, narrowing to a point just behind the axis where they do not unite. The axis is about five-sixths of the length of the pygidium, lanceolated, flattened, more elevated than the side lobes of the pygidium. Dorsal furrows distinct. The axis has a small tubercle located on the median line about $\frac{1}{4}$ its length from the front margin. Surface smooth.

Locality. St. John group, Saint John, N. B.

The head of this species approaches that of *A. neon*, Hall & Whitfield.



NORTH AMERICAN SPECIES OF AGNOSTUS.

AGNOSTUS ACADICUS var. DECLIVIS Matthew, 1885. Pl. IX, fig. 8. The author compares this species with *A. secretus* Walcott.

AGNOSTUS REGULUS Matthew, 1885. Plate X, fig. 11.

Diagnosis.—Head elongate, semi-elliptical, with straight sides, posterior contour broken by the projecting glabella, and narrow occipital ring. Dorsal furrow distinct, marginal furrow and limb sharply defined; the latter diminishes towards the posterior angles of the head. Glabella large, consisting of two lobes; the anterior lobe semi-circular, wider than the posterior lobe, elevated above the general contour of the surface and undulate with broad furrows, radiating from the back of the lobe; posterior lobe flattened, cylindrical, with a faint broad median transverse furrow interrupted at the summit of the glabella by a node, elongated on the line of the axis. The cheeks are narrowed in the middle, there being a crescent-shaped limb in front of the anterior lobe of the glabella, and an expanding cheek on each side of the posterior lobe of the glabella.

The pygidium is elliptical. The axial lobe large, high, obtusely clavate, constricted in the centre and divided into three lobes; the middle lobe is larger than the combined length of the other lobes, and has a median ridge-like tubercle. This lobe is indented in the middle of its length on each side by a short furrow; the anterior lobe is narrow and ring-like; the posterior lobe is sublunate. Limb distinct. The side lobes of the pygidium narrow in rear to conform with the axis.

Locality. St. John group, at Portland, Hanford and Porter's brook, St. Martin's.

This species is of the type *A. rex* Barr.

Section **PARVIFRONTES.**

AGNOSTUS UMBO Matthew, 1885. Plate X, fig. 9.

Diagnosis.—Head broadly transversely elliptical, high and contracted behind, sloping from the glabella in all directions. Marginal fold and furrow strongly marked. Dorsal grooves distinct. Glabella suborbicular, rounded in front, and behind bearing a small tubercle on the axial line, $\frac{1}{3}$ from the front. Length of the glabella $\frac{1}{2}$ that of the head. Pygidium semi-elliptical. Dorsal and marginal furrows deeply impressed; axis conical and greatly elevated above the rest of the pygidium; it bears a small tubercle $\frac{1}{3}$ from the front. The limb is rather wide at

the extremity of the pygidium, and is rounded at the anterior corners.

Locality. St. John group, at Porter's brook.

This species is of the type *A. parvifrons* Linrs.

Section III, **LIMBATI**. General form subquadrate, head has a broad limb, basal lobes large. The cheeks in front of the glabella are not divided by a central groove or grooved at the sides. The pygidium is usually produced into lateral spines. (*Agnostus rex* Barr, pl. x fig. 13).

Series A. (**REGII**). Distinguished by its broad limb, diminishing cheeks and side lobes of the pygidium. Both the anterior lobe of the glabella and the posterior lobe of the pygidium expand. (Type *Agnostus rex* Barr).

Series B. (**FALLACES**). This series has a smaller head, and moderately broad limb. Cheeks large; basal lobes rather large with a broad posterior lobe to the axis of the pygidium. (Type *Agnostus fallax* Linrs. pl. x, fig. 2).

AGNOSTUS VIR Matthew, 1885. Pl. x, fig. 14.

Diagnosis.—Head elongate, semi-elliptical, with straight sides and angulated behind. Dorsal furrow distinct. Marginal fold and groove rather flat and broad. Glabella subconical, obtuse in front, expanded behind. Length about five-sevenths of that of the head. The anterior lobe of the glabella is about two-fifths of its length; it is elliptically rounded in front, and obtusely behind; the posterior lobe is narrowed behind, and in that part is decidedly elevated above the rest of the head; a sigmoid furrow cuts off a depressed basal lobe on each side. The cheeks are moderately elevated, and of equal width all around the glabella.

The thorax consists of two segments, the first is divided into three lobes of which the outer pair is globose, the axis is elongated, transverse and indented on the front side by two strong furrows extending ½ way across; the second segment is similar to the first, except that there are no grooves on the axis.

The pygidium is subquadrate, and armed with two lateral spines; its width one-fifth greater than its length. Axis cylindro-conical, obtusely pointed behind, and bears an elongated tubercle pointed backwards. The side lobes of the pygidium are about ½ the width of the axis and narrowed towards the posterior end of the pygidium, where they connect. The marginal furrow

increases in width going backwards as far as the posterior lateral angles, where it is as wide as the lateral lobe of the pygidium, but narrows again towards the extremity of the pygidium. The limb increases in width from the front as far as the lateral spines, behind which it is constricted; at the anterior end it is angulated towards the axis, in the rear third broadly rounded.

Locality. St. John group, Portland and at Hanford brook, St. Martin's.

The species differs but slightly from *Agnostus fallax* var. *ferox* Tullb. from the Scandinavian formation at Andrarum with *Paradoxides tessini.*

AGNOSTUS VIR var. *concinnus* Matthew, 1885. Plate IX, fig. 13.
This variety varies but slightly from *Agnostus vir.*

DIKELOCEPHALUS ZONE.
Section **LONGIFRONTES.**

AGNOSTUS AMERICANUS Billings, 1860.

Syn. *Agnostus richmondensis* Walcott. Plate IX, figs. 5 and 11.

Diagnosis.—Head oblong, semi-oval, rather strongly convex, most elevated at the posterior quarter of the length, thence descending with a depressed convex slope in all directions to the sides and front. Limb very narrow. The glabella is elongate oval, width ⅓ that of the whole head, length rather more than ⅔ the length of the head. It has two transverse furrows which completely or partially divide it into three lobes. The anterior furrow extends all across at ⅓ or a little more of the length from the front. The posterior furrow is interrupted in the middle, and is only distinctly seen on each side, penetrating ⅓ the width, while its position is a little in advance of the posterior third of the length of the glabella. The space between the two inner extremities of the posterior furrows is occupied by a low conical tubercle, with the apex directed backwards. Basal lobes small and triangular. Dorsal groove distinct. Cheeks divided in front of the glabella by a furrow. The surface is ornamented by from 15 to 20 irregular, slightly impressed radiating rugose striæ. The pygidium is striated like the head. The axis has three lobes with an elongated median tubercle, extending across the anterior and middle lobes; the posterior lobe is equal in size to the other lobes.

Locality. Point Levis, Quebec.

This species approaches *A. trisectus* Salter, which occurs at Andrarum, Sweden with the genus *Peltura.*

AGNOSTUS CANADENSIS Billings, 1860. Plate IX, fig. 9.

Diagnosis.—Head obtusely oblong, semi-oval, width a little greater than the length, a concave border nearly as wide as the glabella all around. Glabella in width less than ½ the width of the head, and in length a little more than ⅔ the length of the head. Basal lobes small. The transverse furrow marking the frontal lobe of the glabella is located a little in advance of the mid-length; the tubercle is obscure and appears to be indicated by the small indentation in the middle of the transverse furrow. The cheeks are separated in front of the glabella by a furrow.

The author doubtfully figures a pygidium of this species. It has a similar form to that of the head of *A. canadensis* with the concave border all around the margin. The axis is obtusely clavate, and marked with two joints. The posterior joint is large and convex, extending quite to the concave border, where it is full half as wide as at the furrow which divides the two joints. The tubercle is situated in the transverse furrow and makes a small indentation in the edge of the posterior joint.

Locality. Point Levis, Quebec.

AGNOSTUS COMMUNIS Hall and Whitfield, 1877. Plate IX, fig. 15.

Diagnosis.—Head subparaboloid, wider than long. Surface strongly convex. Glabella nearly equaling ⅓ of the width of the head; anterior third separated from the posterior lobe by a faint, transverse furrow. Central part of the glabella ornamented by an elongated and angular tubercle. Dorsal furrow distinct. Cheeks separated in front of the glabella by a groove. Basal lobes triangular. Limb flattened. Thorax unknown.

The pygidium with a flattened limb, which is ornamented with lateral spines. Surface strongly convex; in the anterior half, the dorsal furrow being directed gently inward for half their length, and then suddenly deflected outward, with a slight curvature, becoming obsolete a little behind the middle of the length. An elongated angular node marks the axis near its anterior margin. Surface of the head and pygidium smooth.

Locality. White Pine, Nevada.

This species is of the type *Agnostus cyclopyge* Tullberg.

AGNOSTUS COLORADENSIS Shumard, 1861. Plate IX, fig. 16.

The description was drawn from a single example found in Burnet county, Texas, near the mouth of Morgan's creek; the

author states that there is no fissure extending from the glabella to the anterior margin. The absence of this groove may be due to the state of preservation. This species agrees in every other respect with *A. neon*. *Agnostus neon* differs from *A. communis* in minute points, especially in the absence of the tubercle on the glabella.

AGNOSTUS ORION Billings, 1860 (cf. *A. pisiformis* Linné). Plate IX, fig. 12.

Diagnosis.—Length and breadth about equal, sub-circular, convex, a very narrow margin all around. Glabella not quite ⅔ the whole length, very convex; a transverse furrow at one-third the length from the apex; small triangular basal lobes without a median tubercle. Cheeks divided in front of the glabella by a furrow.

Locality. Point Levis, Quebec.

The same term was used by Barrande in 1846 for a species of this genus. If this species differs from *A. pisiformis* it is only in the absence of the median tubercle, which may be due to its state of preservation. There is a slight indication of the tubercle on one of my cabinet specimens from Point Levis. A pygidium from the same locality is similar to that of *Agnostus pisiformis*.

AGNOSTUS JOSEPHA Hall, 1863. Plate IX, fig. 17.

Diagnosis.—Head semi-elliptical, margined by a flattened or concave narrow limb; genal angles produced into short spines. Glabella prominent, narrow, extending about ⅔ the length of the head, and crossed by a shallow furrow near the anterior end. The posterior lobe is marked by an oblique furrow on each side; a small node on the summit at the anterior termination. The triangular space on each side between the transverse and oblique furrows is like-wise elevated into a low node. The posterior central portion is gibbous. The basal lobes small and triangular in form. Cheeks divided in front of the glabella by a furrow. Pygidium of the same form as the head. Axis prominent, subquadrate, wider than long, nearly ⅓ the length of the pygidium, bearing a node or short spine on its posterior extremity; sides and body of the pygidium, outside of the axis, highly convex.

Locality. Trempealeau and elsewhere on the Mississippi about lake Pepin, Wisconsin. The species occurs with *Anomocare wisconsensis* and *Ptychaspis granulosa*.

AGNOSTUS RICHMONDENSIS Walcott, 1884. Plate IX, fig. 11.

Diagnosis.—Head moderately convex, length and breadth equal. Glabella $\frac{3}{4}$ the length and a little more than $\frac{1}{3}$ as wide at the base than the width of the head; elongate, conical in outline. strongly defined by the dorsal furrows, with the anterior third separated by a distinct transverse furrow; a little less than mid-way between this furrow and the posterior margin, a short furrow penetrates from each side towards the base of a minute tubercle situated on the median line. Basal lobes small, triangular. Cheeks more convex than the glabella, separated in front of the glabella by a furrow. Limb narrow. Surface ornamented by slightly irregular depressed lines that indent the surface from the margin nearly to the edge of the strong dorsal furrows. Surface smooth under an ordinary magnifying power.

Locality. Prospect mountain, Nevada.

This species is identical with *Agnostus americanus* Billings.

AGNOSTUS MALADENSIS Meek, 1873, aff. *Agnostus josepha.*

The author proposes this name for a species from Malade City, Utah, which is closely allied to *Agnostus josepha* Hall, except that the specimens do not exhibit the spines on the genal angles of the head; the author remarks "none of which are in a condition to remove all doubt on this point."

Section LIMBATI.

AGNOSTUS BIDENS Meek. Plate X, fig. 5.

Diagnosis.—Head moderately convex, slightly wider than long, bordered by a rounded margin with a strongly defined marginal groove. Glabella convex, narrow, more than $\frac{2}{3}$ the length of the head, converging anteriorly, sub-angular in front; two oblique furrows posterior to the center enter from each side, and unite just in advance of a small node, on the center of an elevation, defined behind by a transverse furrow that bends backwards; between this furrow and the occipital furrow a narrow band extends, widening out laterally, forming the basal lobes. Dorsal furrow distinct. Cheeks convex and sloping rapidly to the marginal groove from the somewhat elevated central portion. Thorax unknown. The pygidium is armed with lateral spines, and is strongly convex. Axis conical, extending more than $\frac{2}{3}$ of the entire length, ornamented with an elongated, angular tubercle on the

anterior portion, with a transverse furrow just before it, separating a narrow anterior portion; in some examples a faint transverse furrow crosses back of the tubercle. Surface of the head and pygidium finely granulose.

Locality. Gallatin City, Montana, also in the Eureka District of Nevada and elsewhere.

AGNOSTUS TUMIDOSUS Hall and Whitfield, 1877. Plate x, fig 8.

Diagnosis.—Head highly dome-shaped in outline, slightly contracted near the occipital border, very convex. Limb narrow, flattened. Dorsal furrow distinct. Glabella small, less than $\frac{2}{3}$ as long as the head, conical and very convex, especially tumid in the lower part; the central tubercle marked near its edge by a very slight line which presents the appearance of a border surrounding it. Frontal lobe about $\frac{1}{4}$ of the length of the glabella. Basal lobes triangular and minute. Thorax unknown. The highly dome-shaped outline with the form and markings of the glabella distinctly mark this species.

Locality. Eureka, Nevada. The species is of the type *A. quadratus* Tullberg.

AGNOSTUS INTERSTRICTUS White, 1874. Plate x, fig. 6.

Diagnosis.—This species of the type *A. fallax* Linrs. is elliptical in form with a smooth surface. The head is broader than long. Limb narrow, forming a narrow linear depression between it and that portion of the head which it incloses. Glabella bilobed, conical, well defined by the dorsal furrows, and sharply rounded in front. A minute tubercle on the median line; near the posterior end; the frontal lobe is marked off by a shallow transverse furrow. Thorax of two joints, narrower than the head and pygidium, giving the body the appearance of being constricted at the middle. Axis broad, both its joints tumid at the ends, where they reach the dorsal furrows; lateral lobes very narrow, pleuræ about as wide as long, each pleuræ tumid and rounded at the extremities. Pygidium in form like the head. Axis a little longer than the glabella, moderately convex, with a minute tubercle on the median line near the anterior end. Sides between the marginal furrow and axis convex. The lateral angles of the pygidium are produced into sharp spines. The basal lobes of the glabella are very minute.

Locality. Antelope Springs, Utah.

Section **LÆVIGATI**. The dorsal grooves marking the glabella and axis of the thorax and pygidium, are wanting or faintly indicated. Crust smooth, sometimes with slight indications of striæ. Limb on the head disappearing; on the pygidium it becomes broad. (*Agnostus lævigatus*. Dalm., plate x, fig. 3).

AGNOSTUS DISPARILIS Hall, 1863. Plate x, fig. 15.

Diagnosis.—Head semi-elliptical, convex towards the posterior side, and abruptly sloping in front; length and breadth nearly as 3 to 4, a little concave on the posterior margin and marked near the edge by a narrow groove on each side of the middle; the centre slightly elevated close to the margin. The limb is a little wider in front than at the sides. The pygidium (?) is a little wider than long. The trilobation extends nearly to the posterior extremity, and is separated from it only by a narrow border. The axis is fully once and a half as wide as the side lobes, somewhat flattened on the summit, and very distinctly limited by the dorsal furrows. The pygidium figured with this species may be that of the genus Microdiscus.

Locality. Oseola Mills, on the St. Croix river, Wisconsin.

AGNOSTUS PARILIS Hall, 1863. Plate x, fig. 4.

Diagnosis.—Head semi-elliptical; length and breadth about equal, very convex in the posterior part, and curving downwards to the anterior margin. The central portion of the posterior part is limited by a faint curving groove; and anterior to its limits there is a slight elevation, which may have a node on the surface of the crust. The posterior margin, just within the angles, is produced in a minute node. The limb gradually expands from the posterior angles to the front, where it becomes well defined. The pygidium is slightly truncated at the anterior angles, the marginal rim narrower towards the articulating border. The central part is slightly more elevated and limited by furrows diverging from the anterior margin. On the median line, at a point ⅓ the length from the front margin, there is a distinct elongated tubercle.

Locality. Shores of lake Pepin.

AGNOSTUS PROLONGUS Hall and Whitfield, 1877. Plate x, fig. 10.

Diagnosis.—Head elongated, or very high dome-shaped in outline. Surface depressed, convex in front and gradually rising to near the occipital border, where it becomes low, tumid. Glabella

very indistinct, of conical form, with triangular basal lobes. Limb narrow, somewhat rounded, gradually fading out along the postero-lateral angles. Pygidium (?) much like the head, but much shorter in proportion to its width. The axis occupies more than ⅓ of the width, short and rounded, obconical, ornamented by a node in its upper end, and divided across by a doubly curved transverse furrow near the lower end. Dorsal furrows distinct. Limb flattened.

Locality. Eureka, Nevada.

Section FALLACES.

AGNOSTUS SECLUSUS Walcott, 1884. Plate X, fig. 16.

Diagnosis.—Head strongly convex, a little longer than wide, with a slight contraction posteriorly. Limb narrow with a distinct groove between it and the cheeks. Dorsal furrows well defined. Basal lobes distinct. Glabella about half the length of the head, strongly convex and squarely truncated in front; at about the anterior third a broad, short furrow penetrates on each side a short distance, and posteriorly a rounded node is separated from each lateral angle by slight furrows, forming the basal lobes. The cheeks slope rapidly towards the marginal groove, on the sides and more gradually to the front. Surface finely granulose.

Locality. Secret Canon shales, Eureka District, Nevada.

ASAPHUS ZONE.

Section IV, ARTHRORHACHIS, type *Agnostus tardus* Barr.

AGNOSTUS GALBA Billings, 1865. Plate IX, fig. 6.

The author describes in The Palæozoic Fossils of Canada, Vol. 1, 1865, p. 291, *Agnostus galba* and *A. fabius* from Table Head and Pistolet bay, Newfoundland. Both these species are of Lower Siluric types, the first of *Agnostus tardus* Barr, and the second of *A. lentiformis* Ang. The species appear with the genera *Asaphus*, *Illænus* and *Triarthrus fischeri*, etc.

Diagnosis.—Head strongly convex. Limb narrow. Glabella convex, strongly elevated above the general surface, occupying about ⅘ of the whole length of the head. Smooth, no tubercle, but with slight indentations on each side, at about the mid-length. Dorsal furrows distinct. Basal lobes triangular. Pygidium in contour and convexity, like the head. Axis strongly convex, well defined all round by the dorsal furrows; a furrow runs all across at ⅓ the length from the apex; a short one on each side at ⅔ the

length from the apex. The tubercle forms a longitudinal medium lobe in the anterior $\frac{2}{3}$ of the axis. The tubercle is at the anterior margin, slightly elevated above the general convexity of the axis. it is less elevated just over the anterior pair of furrows, but behind this point it rises to twice the hight and terminates abruptly at the posterior furrow. The anterior lobes of the axis are distinctly separated from the tubercle by a narrow groove; the second two are not. Surface apparently smooth, but with indications of small wrinkles which unite with each other, so as to give a reticulated aspect, similar to that of *A. reticulatus* Ang. The species differs from *A. tardus* Barr, in having a shorter axis in the pygidium, and in having the node of uniform hight its whole length.

AGNOSTUS FABIUS Billings, 1865. Plate IX, fig. 10.

Diagnosis.—Head semi-elliptical, uniformly and moderately convex. Limb very narrow. Glabella scarcely elevated above the general surface, not defined in front; obscurely so in the posterior half by the dorsal furrows, which are parallel, and disappear about the middle of the head. Basal lobes small, triangular. Pygidium slightly more elongated than the head. Limb narrow, flat. Axis about $\frac{1}{3}$ the whole width; it has two pairs of transverse furrows, the posterior reaching the median line, where there is a small rounded tubercle, located slightly behind the mid-length of the axis. The anterior furrows are half way between the tubercle and the front margin, their inner extremities separated by about one-third the width of the axis.

STRIATION OF ROCKS BY RIVER ICE.*

J. E. TODD, Vermillion, S. Dak.

Sixty years ago the striation of rocks was commonly ascribed to the action of floating ice. For the past twenty-five years these same markings have as generally been referred to the action of land-ice. So much is this the case now, that careful discriminations seem to be largely neglected. Very few observations have been reported, which are clearly referable to glacio-natant action. While it is quite generally admitted that berg-floe, or river-ice

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may striate, cases are rare where they have been shown to do such work.

Croll, in "Climate and Time," pp. 272-279, reviewing the observations of Campbell and others about the gulf of St. Lawrence at various points, and along the St. Lawrence and Ottawa rivers, concludes that floating ice does not striate. The only case he admits is one seen by Lyell at cape Blomidon, on the west side of the Basin of Mines, in a tidal channel where the conditions were similar, as we understand, to those in a river.

Lyell, after searching diligently along the river below Quebec and at the falls of Montmorenci, concludes as follows: "In none of these places were any long, straight grooves observable, and I feel persuaded that any degree of freedom of motion in the rocky fragments forced along by small pieces of ice, or by flood of water, would be quite incompatible with the mechanical effects exhibited in what are called glacial grooves." (Travels in North America, 1841-2, Vol. 2, p. 115). From his method of speaking, it seems that he may have found striæ, but he was not so much endeavoring to decide whether the ice *scratched* the rocks, as to determine if it could imitate so-called glacial *grooving*.

Chamberlin, in his Rock Scorings of the Great Ice Invasion, doubtfully refers some scratches in western New York, to the agency of ice-bergs. (7th Annual U. S. G. S., p. 166).

Little has been published, so far as the writer has discovered, on striation by floating ice, and still less about the action of river-ice. It has been his privilege to gather several interesting facts which have the greater importance because of their rarity.

Ten years ago, at Running Water, S. D., I first saw striæ on chalk-stone a few feet above low water in the Missouri, so situated that they could not be referred to glacial action, and to nothing ancient. The scratches were some of them 10 inches long, and bore S. 73° E. They are on the north side of the river at the foot of cliffs above the landing.

A few seasons after, I found unusual scratches among the many referred to glacial action, near Sioux Falls, Dak. They were deeper and rougher, with tapering ends and upon a boss of rock, apparently eroded from the south instead of the north. They were only a few feet above the present Big Sioux, a few rods distant. The longest were about 10 inches long, their direction, N. 57° W., *i. e.*, parallel with the course of the river.

As both these localities were within the glaciated area, and especially the latter, on the same level with striæ commonly referred to the action of land ice, their origin remained undecided in my mind.

I sought for light upon the problem at every opportunity, as on limestone ledges along the Platte and Missouri rivers, but in vain.

During the past season, it was my privilege to visit Cape Girardeau, Mo., and Grand Tower, Ill., while employed on the geological survey of the former state. At Cape Girardeau, I found upon the ledges a little above low water, numerous scratches several inches long, having a direction S. 10-35° E., corresponding to the course of the river opposite. Here again there was doubt as to their origin, because although beyond the limits of extreme glaciation, it was not impossible that they might have been formed by artificial means, the slipping of pike or anchor, or the grazing of boats. They were near the main landing.

The next day, I was rejoiced to find a much finer exposure of similar markings, about three miles above Grand Tower, on the east side of the river. Here everything seemed to conspire to give an unequivocal affirmative answer to the question, whether river ice did ever striate rocks.

There is there a hard, even-topped stratum of dark limestone, jutting from the bank several yards, and dipping at a slight angle up stream and toward the bank. The steep bank, upon it and extending further up the stream, is faced with large sandstone boulders. The dip of the rocks is 4-6° E. NE. The principal seams of the rock are N. 10-12° E. The surface, which was quite generally planed and striated, was 10 feet wide on an average, and 60-75 feet long. The direction of most of the striæ was S. 10-11° W., and of a few, S. 18° W. The striated surface reached from the surface of the water up 2-3 feet above that level. A small patch toward the lower end was scratched S. 56° E. The striæ were, if anything, more strictly parallel than in most glacial striæ. They were short, rarely more than three inches long. This was mainly due, it would seem, to the nodular and much cracked nature of the stone. One other peculiarity of the stone affected the form of the markings. Scattered through the rock were small black grains, as if of iron oxide. These usually headed the narrow ribs separating the striæ.

As if to leave no doubt, a long deep scratch, about four feet in length and about as high above the ledge, was made doubtless by the same agent, viz., river-ice, on the nearly vertical face of a large boulder. This was in the same direction as the striæ on the ledge below.

The condition obtaining here and not in some of the other localities I had examined was the occurrence of numerous siliceous boulders at the river margin, a little up-stream from the ledge showing abrasion.

After this demonstration of the efficiency of river-ice, I had no difficulty in ascribing the cases previously noted to the same cause. I would refer some, reported by others, to probably the same cause, viz.: Some reported to me by Prof. J.W. Spencer, as found at low water mark, at St. Louis, also some, reported to me some years since, by Prof. S. T. Trowbridge, from the vicinity of Glasgow, Mo. And less confidently those formerly seen and published by Dr. C. A. White, occurring at low water, at Omaha, Neb.

Nor is the story complete, without adding an interesting case most recently observed, at Wellington, Mo. There, on a ledge near low water, not far from the depot, are a very few markings on a rough horizontal ledge of limestone. The patches striated were in each spot less than three inches across, but the markings in each were parallel to one another. In the first spot the direction was S. 45° E., on a surface dipping 4-5° to E. In the direction of the striæ and 14 inches away was another patch, level, and striated S. 61° E.; and following that direction 18 inches, a patch sloping upward and striated S. 77° E. was found. Possibly this was all done by one floating block.

The foregoing observations, seem to me to warrant the following conclusions:

1. Planation and striation are sometimes the work of river-ice, armed with erratics.

2. The localities most favorable for this phenomenon seem to be, on the outside of a bend, or near a strong current, near low water mark, and below a point where siliceous erratics lie near the water level.

3. The dynamical conditions necessary are probably a sudden breaking up of the ice, before it is rotted by thawing, and with a flood to wield it. This, however, is largely conjectural. The proper conditions do not often occur in our present western streams.

As both these localities were within the glaciated area, and especially the latter, on the same level with striæ commonly referred to the action of land ice, their origin remained undecided in my mind.

I sought for light upon the problem at every opportunity, as on limestone ledges along the Platte and Missouri rivers, but in vain.

During the past season, it was my privilege to visit Cape Girardeau, Mo., and Grand Tower, Ill., while employed on the geological survey of the former state. At Cape Girardeau, I found upon the ledges a little above low water, numerous scratches several inches long, having a direction S. 10-35° E., corresponding to the course of the river opposite. Here again there was doubt as to their origin, because although beyond the limits of extreme glaciation, it was not impossible that they might have been formed by artificial means, the slipping of pike or anchor, or the grazing of boats. They were near the main landing.

The next day, I was rejoiced to find a much finer exposure of similar markings, about three miles above Grand Tower, on the east side of the river. Here everything seemed to conspire to give an unequivocal affirmative answer to the question, whether river ice did ever striate rocks.

There is there a hard, even-topped stratum of dark limestone, jutting from the bank several yards, and dipping at a slight angle up stream and toward the bank. The steep bank, upon it and extending further up the stream, is faced with large sandstone boulders. The dip of the rocks is 4-6° E. NE. The principal seams of the rock are N. 10-12° E. The surface, which was quite generally planed and striated, was 10 feet wide on an average, and 60-75 feet long. The direction of most of the striæ was S. 10-11° W., and of a few, S. 18° W. The striated surface reached from the surface of the water up 2-3 feet above that level. A small patch toward the lower end was scratched S. 56° E. The striæ were, if anything, more strictly parallel than in most glacial striæ. They were short, rarely more than three inches long. This was mainly due, it would seem, to the nodular and much cracked nature of the stone. One other peculiarity of the stone affected the form of the markings. Scattered through the rock were small black grains, as if of iron oxide. These usually headed the narrow ribs separating the striæ.

4. Usually the striæ are parallel, as much so as in glacial action, and commonly on surfaces dipping up stream, but occasionally upon limited areas dipping down stream.

While these facts may have no direct significance of practical value, they indirectly throw much light upon the possible origin of the extra-morainic drift, and of some ancient striated surfaces outside of the moraines.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Bulletin of the Geological Society of America. Proceedings of the Summer Meeting held at Washington, August 24 and 25, 1891. H. L. FAIRCHILD, Secretary. Vol. iii, pp. 1-152; issued March 9, 1892.

A fine portrait of Prof. Alexander Winchell, the deceased president of the society, forms the frontispiece of this brochure, which contains a memorial sketch of him by his brother, Prof. N. H. Winchell.

Many papers that were read at the meeting, a considerable number of them being by foreign geologists who attended the International Geological Congress, are presented, either entire or in abstract, including notes on a geologic map of South America, by Dr. Gustav Steinmann, of Freiburg, Germany; Thermometamorphism in Igneous Rocks, by Alfred Harker, of Cambridge, England, discussing a great volcanic series of Ordovician age in the English Lake District; The Plant-bearing Deposits of the American Trias, by Lester F. Ward, these deposits in the Connecticut valley, in New Jersey and Pennsylvania, Virginia and Maryland, North Caroline, and New Mexico and Arizona, being all referred to the upper Keuper, near the summit of the Triassic system; Studies in Problematic Organisms—the genus *Scolithus* (with numerous figures in the text), by Joseph F. James, who regards these worm-burrows as valueless for correlations; The Tertiary iron ores of Arkansas and Texas (with a map), by R. A. F. Penrose, Jr., who concludes that the limonite ores as now found are the products of the oxidation of original iron carbonate and sulphide; Sandstone Dikes in northwestern Nebraska (with illustrations in the text), by Robert Hay; The *Eurypterus* beds of Oesel as compared with those of North America, by Dr. Friedrich Schmidt, of St. Petersburg, Russia; On the marine beds closing the Jurassic and opening the Cretaceous, with the History of their Fauna, by Prof. Alexis Pavlow, of Moscow, Russia; Quaternary Changes of Level in Scandinavia (with a map), by Baron Gerard de Geer, of the Geological Survey of Sweden (see the GEOLOGIST, Oct., 1891, p. 236); The "Black Earth" of the Steppes of southern Russia, by Prof. A. N. Krassnof, of Clarkow, Russia, a most interesting comparison of the *chernozem* with the black prairie oil of the Missi*ssi*ppi basin; On the existence of the *Dinotherium* in Rou-

mania, by Prof. Gregoire Stefanescu, of Bucharest, Roumania; The Elæolite-Syenite of Beemerville, New Jersey, by James F. Kemp; Notes on the Texas-New Mexican region, by Robt. T. Hill, an admirable paper describing: (1) the Lafayette formation of gravel, sand and silt, ranging in altitude up to 5,500 feet and averaging 200 feet in thickness, on the Llano Estacado, the Edwards Plateau, and the Washington Prairies, (2) Lafayette and Columbia fluvial and lacustrine beds, ranging together to thicknesses of 500 to 1,000 feet, in basins of western Texas and New Mexico, surrounded by faulted and tilted mountain blocks, and (3) volcanic areas of eastern New Mexico, having lavas which overlie these late Tertiary and Pleistocene formations; The Relations of the American and European Echinoid Faunas, by J. W. Gregory, of the British Museum of Natural History, concluding that these continents have been so united at times during the Miocene and Pliocene periods as to permit their echinoid faunas, before widely different, to become closely related, in a manner "wholly incompatible with the theory of the permanence of the great ocean basins;" The Missouri Coal Measures and the Conditions of their Deposition (with a map and seven ideal sections in the text), by Arthur Winslow; The Pelvis of a *Megalonyx* and other bones from Big Bone Cave, Tennessee, by James M. Safford (see the GEOLOGIST, Oct., 1891, p. 232); The Cienegas of southern California, by Eugene W. Hilgard, describing alluvial fans of gravel, sand, and silt, which become reservoirs, with springs issuing on their lower portions and producing spots of verdure (cienegas) in otherwise arid tracts; The Chattahoochee Embayment, by Lawrence C. Johnson, describing Tertiary and Quaternary formations in western Florida; Peculiar geologic processes on the Channel Islands of California, by Lorenzo G. Yates; Inequality of Distribution of the Englacial Drift, by Warren Upham (see the GEOLOGIST, Oct., 1891, p. 239); Effects of Drought and Winds on Alluvial Deposits in New England, by Homer T. Fuller (l. c., p. 239); and A Deep Boring in the Pleistocene near Akron, Ohio, by E. W. Claypole (l. c., p. 239).

Three papers read at this meeting are printed in separate brochures, namely, Preliminary Notes on the discovery of a Vertebrate Fauna in Silurian (Ordovician) strata (pp. 153-172, with three plates, issued March 15, 1892), by Charles D. Walcott, describing remains of placoderm fishes in Lower Trenton strata at Canyon City, Colorado; Certain extra-morainic Drift Phenomena of New Jersey (pp. 173-182), and On the northward and eastward extension of pre-Pleistocene Gravels of the Mississippi Basin (pp. 183-186), both by R. D. Salisbury, issued March 31, 1892 (see the GEOLOGIST, Oct., 1891, p. 238).

The Labrador Coast: A journal of two summer cruises to that region, with notes on its early discovery, on the Eskimo, on its Physical Geography, Geology, and Natural History. By ALPHEUS SPRING PACKARD. pp. 513; with many maps and illustrations. (New York: N. D. C. Hodges, publisher, 1891). This volume well presents nearly all that is known concerning the geography, geology, fauna (both of land and sea), and flora of Labrador. The author's observations and discussion of the glacial phenom-

ena are especially valuable. Several of the maps, based largely on explorations by the Moravian missionaries, have been drafted for this work and are superior to any previously published.

Exploration on Grand River, Labrador. By AUSTIN CARY. (Bulletin, Am. Geog. Soc., Vol. xxiv, pp. 1-17, with a map; March 31, 1892). The Bowdoin College expedition in 1891 to the falls of the Grand river in Labrador, of which a brief narrative is given in an appendix of Prof. Packard's volume, is here more fully reported. The largest fjord of Labrador, about 150 miles long, known as Hamilton Inlet, terminating in lake Melville, receives at its head the Grand river. The distance along the river from its mouth to the falls is nearly 300 miles. For nine miles next below the falls the river runs in a narrow postglacial cañon, 300 feet deep close to the falls and 800 to 1,000 feet deep at its lower end, where it opens, like the gorge below the falls of St. Anthony on the Mississippi, into a wide preglacial valley, whose upper part is occupied by a comparatively small tributary. The cañon is eroded in the hardest crystalline rocks, which form a plateau in that region about 2,000 feet above the sea; and the amount of its erosion, as of the gorges below Niagara and the falls of St. Anthony, affords a measure of the length of postglacial time. The vertical fall, probably due to systems of joints in the rocks, was estimated by Mr. Cary to be somewhat less than 200 feet, but has since been more reliably determined to be about 300 feet. Strong rapids extend several miles both below and above the falls.

On the Osteology of Mesohippus and Leptomeryx, with Observations on the Modes and Factors of Evolution in the Mammalia. By W. B SCOTT. (Journal of Morphology, Vol. v, No. 3, pp. 104, with two double plates and nine figures in text).

This is a worthy sequel to the admirable memoir on *Pæbrotherium* by the same author, briefly noticed in the November number of the GEOLOGIST.

The first 41 pages are occupied with a study of *Mesohippus* in its relations to existing equine forms.

The typical species of this genus *M. bairdii*, first referred by Leidy, its describer, to the genus *Palæotherium* and later to *Anchitherium*, has usually been referred to the latter genus, but, as has been shown by Scott*, belongs, by the non-invaginate enamel of its incisor teeth, to another genus, for which he has retained the name, *Mesohippus*. The genus *Mesohippus*, originally proposed by Marsh on characters which, so far as different from those of *Anchitherium*, are of merely specific value, is thus saved *literally* "by the skin of its teeth."

Of the two genera, *Anchitherium* and *Mesohippus*, the latter is regarded as the more primitive form, and it is questioned whether the former genus be in the line of equine descent and whether it do not rather form a side branch.

After a detailed description of the parts of the skeleton, a full-page restoration is given, in connection with which Prof. Scott remarks: "The successive genera of the horse species show for the most part a steady

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increase in size from the tiny *Hyracotherium* of the Wasatch Eocene to the great animals of Post-pliocene times. *Mesohippus*, however, has not reached a large stature, advancing beyond its Bridger predecessor, *Pachynolophus*, much less in regard to size than in morphological differentiation; the larger species of the Bridger genus are but little inferior in this respect to the smaller species of the White River form. In spite of its comparatively high degree of differentiation, *Mesohippus* was a very small animal compared with the recent horses, about the size of the Newfoundland dog. The skeleton is essentially like that of existing *Equidæ* in character and appearance, but presents many striking points of difference." Some of these points are as follows: *Mesohippus* as compared with *Equus* is characterized by its smaller skull, shorter face, larger and more anteriorly and inferiorly placed, posteriorly open orbits, its less massive, less opisthocœlous, cervical vertebræ, differently shaped odontoid process, long and well arched back, less flattened ribs, its slenderer limbs and decidedly greater length of hind-limbs relative to fore-limbs than in *Equus*, its complete though slender ulna, its functionally developed second and fourth metapodials and splint-like metacarpal I.

Concluding this part of his paper, the author observes: "There are thus many points of difference as regards the proportionate development of the various parts of the skeleton, between *Mesohippus* and *Equus*, and these divergences, more especially the smaller and differently shaped head and the very slender tridactyl feet, give to the older type quite another physiognomy than that of the recent representatives of the group, even without taking into consideration its very much smaller size. Nevertheless, no one can examine the skeleton of the Miocene genus without being struck by its essentially equine nature; in the teeth alone is the fundamental similarity of plan not apparent at the first glance, though even here a careful examination reveals the connection very clearly. This similarity extends also to the earlier members of the equine series, for *Hyracotherium* from the lower Eocene belongs as unmistakably to this line as do any of the later genera. Indeed, one of the most striking features of this phylum is the way in which its essential features, and even many apparently insignificant details, are, as it were, sketched out in very early times and then gradually elaborated, without deviation and without retrogression, until the final term of the series is reached."

In the second section of the contribution, nineteen pages are devoted to an account of the genus *Leptomeryx*, including description of nearly all of the skeleton with a restoration of *L. evansi* Leidy, and a discussion of the problem of the systematic position of the genus. It is found that in twenty-seven characters that especially mark the tragulines, *Leptomeryx* agrees with them in twenty-one, presenting on the other hand six more or less important points of relationship to the *Pecora*.

Boas' view that the tragulines are a group of simplified ruminants derived from typical members of that series, by which *Leptomeryx* would be considered one of the direct ancestors of the tragulines, is rejected, and it is considered probable that "Leptomeryx is a side-branch of the traguline stem given off before the extreme concentration of the tarsus char-

acteristic of existing members of that stem had been acquired, and which has paralleled more or less exactly the characters of the *Pecora* in certain particulars; *e. g.*, the condition of the auditory bullæ and the constitution of the posterior cannon-bone."

The remainder of the paper consists of two discussions: one "On the mode of evolution in the Mammalia," the other "On some factors in the evolution of the Mammalia."

The first of these is concerned chiefly with the paleontological evidence for parallel and convergent evolution. The evidence seems quite conclusive that both modes have obtained, and "it follows with great probability that many generic groups are not real expressions of relationship, but artificial assemblages of similar forms." The author points out the fallacy of Huxley's dictum that "it is more important that similarities should not be neglected than that differences should be overlooked." The evolution of the types selected for study, though with some fluctuation, is comparatively direct, and the plasticity of mammals is believed to show marked limitation. "In every formation, the majority of species appear to die out without leaving any successors behind them, and too early a specialization would seem to be fatal to the perpetuation of a group. With rare exceptions the progenitors of permanent lines seem to be those forms which have not strayed too far in any direction from the safe middle course."

To the general rule that among mammals differentiation is by reduction in the number of parts, exceptions are noted; and the probability is indicated that evolution does not always proceed at a uniform rate.

The part "On some factors in the evolution of Mammalia" deals chiefly with Weissman's theory of heredity and the "dynamic theory." While commending the former as having called renewed attention to fundamental questions, the author does not accept it, considering that it confuses, rather than explains, the phenomena of heredity. The "dynamic theory," on the other hand, though presenting a difficulty in understanding how changes in the periphery can modify the germ-plasm in such a way as to reproduce the new characters in the offspring, is regarded as much more consistent with the data of palæontology.

RECENT PUBLICATIONS.

II. Proceedings of Scientific Societies.

Proceedings of the Colorado Scientific Society, Vol. III, Part III, 1890, contains: Identification of Dinosaurs from the Denver Group, by Geo. L. Cannon, Jr: A Remarkable Crystalline Compound of Arsenious and Sulphuric Acids, by Richard Pearce; Iron-Ore Beds in the Province of Santiago, Cuba, by F. F. Chisholm; Gold Deposits in the Quartzite Formation of Battle Mountain, Colorado, by F. Guiterman; Geology of the Rosita Hills, Custer Co., Colorado, by Whitman Cross; Fulgurite from the Spanish Peaks, by R. C. Hills; On the Nature of the Chemical Ele-

ments, by Chas. S. Palmer; The Geology of Perry Peak, Colorado, by Geo. L. Cannon, Jr.; A Boulder County Mine, by John B. Farish; Columbite and Tantalite from the Black Hills, S. D., by Wm. P. Headden; Notes on the Discovery and Occurrence of Tin Ore in the Black Hills, S. D., by Wm. P. Headden; On the Quartz Porphyry of Flagstaff Hill, Boulder Co., Colorado, by Chas. S. Palmer and Henry Fulton; Orographic and Structural Features of Rocky Mountain Geology, by R. C. Hills.

Proceedings of the Rochester Academy of Science, Vol I, Brochure II, contains: Notice of a New Meteorite from Louisa Co., Va., by E. E. Howell; Analyses of Kamacite, Tænite, and Plessite from the Welland Meteoric Iron, by J. W. Davison; A Section of the Strata at Rochester, N. Y., as shown by a Deep Boring, by H. L. Fairchild; On the Separation and Study of the Heavy Accessories of Rocks, by Orville A. Derby.

Journal of the Elisha Mitchell Scientific Society, eighth year, 1891; part second, contains: Occurrence of Zirconium, by F. P. Venable; Magnetic Iron Ores of Ashe Co., N. C., by H. B. C. Nitze; The Occurrence of Platinum in North Carolina, by F. P. Venable.

III. Papers in Scientific Journals.

The Canadian Record of Science, Vol. IV, No. 8, contains: Description of a new Species of Panenka from the Corniferous Limestone of Ontario, by J. F. Whiteaves; Notes on the Occurrence of Paucispiral Opercula of Gasteropoda in the Guelph Formation of Ontario, by J. F. Whiteaves; Note on Leptoplastus, by J. F. Matthews; Notes to Accompany a Tabulation of the Igneous Rocks, based on the System of Prof. H. Rosenbusch, by F. D Adams; A Note on the Collection of Sediments in Potable Waters, by R. F. Ruttan; Short Notes on some Canadian Minerals, by W. F. Ferrier.

The Ottawa Naturalist, Vol. V, No. 9, *Jan.* 1892, contains: Inaugural Address: The Work of the Geological Survey of Canada, by R. W. Ells.

The Geological Magazine, Vol. IX, No. 1, *Jan.* 1892, contains: The Lower Devonian Fish Fauna of Campbellton, New Brunswick, by A. Smith Woodward; On the Crystalline Schists of the Lepontine Alps, by Dr. F. M. Stapff; The Fauna of the Olenellus Zone in Wales, by H. Hicks; Reade's Theory of Mountain Building, by A. J. Jukes-Browne; On *Xanthidia* in the London Clay, by E. W. Wetherell.

Feb. No. contains: Note on an Iguanodont Tooth, by E. T. Newton; Note on a New Species of Onychodus, by E. T. Newton; New Hyaline Foraminifera from the Gault, by F. Chapman; Absence of Glaciation in Western Asia and Eastern Europe, by H. H. Howorth; On Certain Highland Gneisses, by George Barrow; Continuity of the Kellaways Beds near Bedford, by A. C. G. Cameron; Nature's Manufacture of Serpentine, by Maj.-Gen. MacMahon; Reply to Prof Blake, by S. S. Buckman.

Mar. No. contains: The Coniston Limestone series, by J. E. Marr; On the formation of Landscape Marble, by H. B Woodward; On the Hirnant Limestone, by L. W. Fulcher; On the Flexibility of Rocks, by G. W. Card.

IV. Excerpts and Individual Publications.

On the Occurrence of Diamonds in Wisconsin, by Geo. F. Kunz. From Bull. Geol. Soc. Am., Vol. 2.

Farmington, Washington Co., Kansas Aerolite, by Geo. F. Kunz and E. Weinschenk. From Am. Jour. Sci., Jan. 1892.

Plea for the Life of the Geological and Mineralogical Survey of Texas, and review of the Charges Preferred against Prof. E. T. Dumble, State Geologist, by J. H. Herndon, 8vo., pp. 40. Austin, Sept. 1891.

Notes on the Genus Acidaspis, by J. M. Clarke. Communicated to the State Geologist, [New York] Dec. 1890.

Observations on the Terataspis grandis Hall, the largest known trilobite, by J. M. Clarke. Communicated to the State Geologist, [New York] Dec. 1890.

Note on the Coronura aspectans Conrad (sp.), the Asaphus diurus, Green, by J. M. Clarke. Communicated to the State Geologist, [New York] Dec. 1890.

The Discovery of Clymenia in the fauna of the Intumescens-Zone (Naples Beds) of Western New York, and its Geological Significance, by J. M. Clarke. From Am. Jour. Sci., Jan. 1892.

A Section of the Strata at Rochester, N. Y., as shown by a Deep Boring, by H. L. Fairchild. From Proceed. Rochester Acad. Sci., Vol. I, 1891.

Reports on Short Excursions made by the Geological Department of the University during the autumn of 1891, by Geo. H. Williams and Wm. B. Clark. In Johns Hopkins University Circulars, Feb. 1892.

The Ward Collection of Meteorites, pp. 75, Rochester, N. Y.

The Filling of Mineral Veins, by J. F. Kemp. From School of Mines Quart., No. 1, Vol. XIII, Nov. 1891.

Theory of an Interglacial Submergence in England, by G. Frederick Wright. From Am. Jour. Sci., Jan. 1892.

The Basic Dikes Occurring Outside of the Syenite Areas of Arkansas, by J. F. Kemp. From Ann. Rep. Geol. Surv. Arkansas, Vol. II, 1890.

Height and Position of Mt. St. Elias, by I. C. Russell. From Nat. Geog. Mag., Vol. III. 1891.

Discovery of Cretaceous Mammalia; part III, by O. C. Marsh. From Am. Jour. Sci., Mar. 1892.

Soil Investigations, by Milton Whitney. From Fourth Ann. Rep. Maryland Agl. Exp. Station.

Association of Apatite with Beds of Magnetite, by W. P. Blake. From Trans. Am. Inst. Min. Eng., Feb. 1892.

Contributions to the Early History of the Industry of Phosphate of Lime in the United States, by Wm. P. Blake. From Trans. Am. Inst. Min. Eng., Feb. 1892.

The Trap Dikes in the Lake Champlain Valley and the Neighboring Adirondacks, by J. F. Kemp and V. F. Marsters. From Trans. N. Y. Acad. Sci., Vol. XI, 1891.

A summary of Progress in Mineralogy and Petrography in 1891, W. S. Bayley. From monthly notes in the American Naturalist.

Tertiary Mollusks of Florida, part II, W. H. Dall. From the Trans. Wag. Free Inst., pp. 201-217, 1892.

Parka decipiens. Notes on specimens from the collections of James Reid, Esq., of Allan House, Blairgowrie, Scotland, Sir William Dawson and Prof. D. P. Penhallow. Trans. Roy. Soc., Canada, Sec. IV, 1891.

Glacial lithograph (from Guthrie's geological collection); an imprint from a glaciated limestone surface, March, 1891.

The Mother Maps of the United States, by Henry Gannett. From Nat. Geog. Mag., Vol. IV, Mar. 1892.

Notes on Palæozoic Crustaceæ, No. 1: On some new Sedalia Trilobites, by A. W. Vogdes. From Trans. St. Louis Acad. Sci., 1891.

Artesian Wells and Water Horizons in Southern New Jersey, by Lewis Woolman. From Ann. Rep. State Geologist of New Jersey for 1890. Trenton, 1891.

A Review of Artesian Horizons in Southern New Jersey, by Lewis Woolman. From Ann. Rep. State Geologist of New Jersey for 1891. Trenton, 1892.

Two Species of Trees from the Post-Glacial of Illinois, by D. P. Penhallow. From Trans Roy. Soc., Canada, Sec. IV, 1891.

V. *Foreign Publications.*

Notes on Crystallites, by Frank Rutley. From Mineralogical Magazine, Vol. IX, No. 44.

The Type Fossils in the Woodwardian Museum, Cambridge, by Henry Woods; 8vo, 180 pp., Cambridge, 1891.

Eclogæ Geologicæ Helvetitiæ, Vol. II, No. 5, Jan. 1892, contains: Alluvions glaciaires, par Du Pasquier.

Verhandlungen der Naturforschenden Gesellschaft in Basel, Bd. IX, Heft 2, contains: Geologische Mittheilungen aus der Umgebung von Lugano, von C. Schmidt und G. Steinmann; Ueber ein zweites Vorkammen von dichtena Vesuvian in den Schweizeralpen, von C. Schmidt; Neuere Funde von fossilen Säugethieren in der Umgebung von Basel, von L. Rütimeyer.

Die Quarzporphyre der Umgegend von Gross-Umstadt, von Christoph Vogel. From Abhandl der Geolog. Landesanstalt zu Darmstadt, Bd., II, Heft 1, 1891.

Sulla Fase Eruttiva del Vesuvio comunciata nel Gingno, 1891, di R. V. Matteucci, Napoli, 1891.

Bulletin de la Société Géologique de France, t. XIX, *Dec.* 1891, contains: La Geologie et la Paléontologie du bassin houiller du Gard, par R. Zeiller; Note sur trois espèces du genre *Scalpellum* du Calcaire Qrossier des environs de Paris, par L. Bertrand; Note préliminaire sur les observations géologiques faites dans l'Asie centrale, par Ch. Bogdanowitch; Sur quelques points de la géologie des Corbières, par L. Carez; Note sur les terrains primaires de Merens, par J. Roussel; Note sur trois nouvelles Bélemnites sénoniennes, par Ch. Janet; Sur le Crétacé supérieur des Pyrénées occidentales, par Stuart-Menteath; Observations sur l'allure des couches dans des Pyrénées françaises, par J. Roussel; Sur les roches à

leucite de Trébizonde, par A. Lacroix; Notes sur quelques roches d'Arménie, par A. Lacroix; Note sur le genre *Echinocyamus*, par J. Lambert; Sur les notes géologiques de M. J. Seunes, par Stuart-Menteath; Sur l'attribution au Carbonifère des schistes à *Oldhamia* du pays de Luchen, par Caralp; Sur les terrains quarternaires des environs de Tiaret, department d'Oran (Algérie), par J. Welsch; Note sur l'origine des gites calaminaires, par A. Lodin; Notice géologique et paléontologique sur le nature des terrains traversés par le chemin de fer entre Dijon et Chalon-sur-Saône, par Parandier.

Feb. No., 1892, contains: Études s'ratigraphiques dans la région du Cap Gris-Nez, par Douvillé et Rigaux; Observations sur la note de M. Stuart-Menteath intitulée; Sur le Crétacé supérieur des Pyrénées Occidentales, par J. Seunes; Réponse à le note de M. Stuart-Menteath intitulée; Sur le notes de J. Seunes, par J. Seunes; Description de deux Crinoides nouveaux du Dévonien de la Manche, par D. P. Œhlert; Remarques sur les gites de phosphate de chaux de la Picardie, par N. de Mercey; Notes recueillies au cours d'une exploration dans l'île de Bornéo, par M. Chaper; Relations stratigraphiques de l'argile à silex, par G.-F. Dollfus; Note sur les conditions dans lesquelles s'est effectué le dépôt de la craie dans le bassin anglo parisien, par Ch. Janet.

Geology and Mineral Resources of the Upper Burdekin, by A. Gibb Maitland. 4vo., 10 pp , with profiles and plate.

The Geology of the Cooktown District, by A. Gibb Maitland. 4vo., 6 pp., 3 colored plates.

Coolgarra Tin Mines and Surrounding District, by A. Gibb Maitland. 4vo., 6 pp., with profile and plate.

Proceedings of the Philosophical Society of Glasgow, Vol. XXII, 1890-91, pp. 374. Glasgow, 1891.

Földtani Közlöny, XXI Kotet, 8-12 Füzet. Budapest, 1891.

Vierteljahrschrift der Naturforschenden Gesellschaft in Zurich, 36th Jahr, Heft 3 und 4. Zurich, 1891.

Neujahrsblatt von der Naturforschenden Gesellschaft auf das Jahr, 1892, XCIV. Zurich, 1892.

CORRESPONDENCE.

ROCKS OF THE NIAGARA AGE IN INDIANA.—In the March (1891) number of the AMERICAN GEOLOGIST, page 178, the writer selected Saint Paul, Decatur county, as a typical locality for the state, giving what was considered to be a complete representation of the Niagara strata. Since then the writer has traced the rocks to the Ohio river and found the fossil layers in the northern part of Jefferson county, on a little stream by the name of Big creek, to be a distinct bed and lower than any strata at St. Paul. This stratum consists of a calcareous shale from ten to fifteen feet in thickness; it immediately underlies the massive homogeneous quarry

bed of St. Paul, Harris City, Greensburg and Osgood. The following is a connected section of the Niagara rocks of the state:

No. 5. Blue shale (The Waldron fossil beds, 10 feet). Seen on Mill creek, a short distance above the point where it flows into Flat Rock.

No. 4. Thinly laminated limestone quarries at St. Paul, thickness 15 feet; containing *Pisocrinus gemmiformis* S. A. Miller; *P. globosus* Ringueberg; "pear shaped crinoid;"* *Stephanocrinus osgoodensis* S. A. Miller

No. 3. Cherty beds, containing thin plates of limestone in which are found the same fossils as in No. 3, thickness 15 feet, on Flat Rock, St, Paul.

No. 2. Heavy laminated quarry rock, containing fossils in No. 3 but not in such profusion, the upper or "flagging" layers containing in addition cystids and large cephalopods, *Gyroceras elrodi* White, *Orthoceras annulatum* Sowerby. St. Paul, Greensburg, Harris City, Osgood and on Big creek, Jefferson county.

No. 1. Calcareous shale, thickness 15 feet. Seen on Big creek, Jefferson county, containing large specimens of *Caryocrinus ornatus*, *Holycystites* and *Stephanocrinus*

It was also stated in the former paper that no Caryocrinus had been found in the state; several small species, which up to date are new, have been found at St. Paul, while bed No. 1 of above section contains Caryocrinus ornatus of enormous size, the hight of the calyx of one specimen seen being three inches.

The following general observations may be made:

In the northern part of the state only small species, such as Pisocrinus, have been found; at St. Paul the specimens are larger and a great number of Swedish genera occur such as Callicrinus, Carpocrinus, etc., and small cystids, while at Greensburg and Harris City Stephanocrinus predominates, and at Osgood the "pear shaped crinoid" reaches its greatest size. In the lowest bed, that on Big creek, Jefferson county, the cystids become enormous in size.

Recently the writer has exchanged specimens with Prof. Gustaf Lindstrom, of Sweden, and finds that the corals of Sweden are nearer those of this lower bed than any other. CHARLES S. BEACHLER.

Crawfordsville, Ind., May 12, 1892.

PRIZES AWARDED BY THE BOSTON SOCIETY OF NATURAL HISTORY.—A grand honorary prize placed at the disposal of the Boston Society of Natural History by the late Dr. William J. Walker "for such investigation or discovery as may seem to deserve it, provided such investigation or discovery shall have been made known or published in the United States at least one year previous to the time of award" has been unanimously awarded to Prof. James D. Dana. In recognition of the value of the scientific work of Professor Dana and in testimony of the society's high appreciation of his services to science the maximum sum of one thousand dollars has been awarded.

For the annual Walker prizes a first prize of one hundred dollars has been awarded to Baron Gerard de Geer, of Stockholm, for an essay entitled "On Pleistocene Changes of Level in Eastern North America," and a second prize of fifty dollars to Prof. William M. Davis of Cambridge for an essay on "The Subglacial Origin of Certain Eskers."

May 2, 1892. SAM'L HENSHAW.

*The "pear shaped crinoid" has been figured by Mr. S. A. Miller in Advance sheets of 17th Indiana report as Bophocrinus howardi.

DELTAS OF THE HUDSON AND MOHAWK VALLEYS.—The interesting letter in your last number (p. 344) by Mr. Taylor, and his able article in the American Journal of Science for March, give very clear descriptions of deltas in the Mohawk valley and of shore lines on the upper Laurentian lakes, which he refers to the presence of the sea since the recession of the ice-sheet. While thanking him for the excellent descriptions of these deltas and shore lines, I wish to offer an alternative view, showing how the Hudson and Mohawk deltas may be well explained by a glacial lake, which seems to me to be the only explanation consistent with the complete absence of Champlain or postglacial marine fossils from these valleys and from all the area of the great Laurentian lakes. This explanation appeals to the receding continental ice-sheet as the northern and northeastern barrier of great glacial lakes in the northeastwardly descending St. Lawrence basin, until the farther departure of the ice admitted the sea into the then depressed St. Lawrence and Ottawa valleys and basin of lake Champlain. These glacial lakes and the Champlain depression of the country northward have been demonstrated by the work of Gilbert, Chamberlin, Leverett and others.

On what portion of the St. Lawrence basin did the ice-sheet continue latest as a barrier of lake Iroquois, the glacial lake which outflowed through the Mohawk valley, and afterward by the way of lake Champlain to the Hudson? This is answered by finding where the ice at the time of its departure was thickest upon the St. Lawrence valley, so that its latest movements were thence southwesterly toward the lake Iroquois and easterly toward the gulf of St. Lawrence; and this area, as shown by the directions of glacial striæ and transportation of the drift, was the vicinity of Quebec.

When the ice blockade was removed, the northward depression of the land, which had been slowly rising (as I have shown in Bulletin, G. S. A., vol. ii, pp. 258-265), was still sufficient to permit the sea to flow in where a great extension of låke Iroquois had previously existed. The incursion of the sea, at a somewhat lower level than had been held by the glacial lake, reached to the south end of lake Champlain, to the Thousand islands at the mouth of lake Ontario, and to Pembroke in the Ottawa valley, seventy-five miles above the city of Ottawa. To these limits the marine fossils of the Champlain submergence are present in beds of clay and sand overlying the till. Their maximum observed hight above the sea is 520 feet at Montreal, from which their upper limit declines southwestward to about 250 feet near the mouth of lake Ontario, southward to probably a less hight at the south end of lake Champlain, and eastward to zero in Nova Scotia. The frequent occurrence of Champlain marine fossils to these limits shows the formerly much increased extent of the gulf of St. Lawrence; but on the other hand the absence of such fossils westward from the mouth of lake Ontario and in the Hudson and Mohawk valleys marks areas where the shore lines and deltas of former bodies of water are referable to glacial lakes, not to the sea. If a strait of the ocean had occupied the Hudson valley at the time of the Champlain submergence, tidal currents must have swept to and fro through the val-

ley, giving the most favorable conditions for the incoming of the marine fauna.

The physical features of the deltas so well described by Merrill, Davis and Taylor along the Hudson and the Mohawk are all satisfactorily attributable to the presence of a glacial lake, which I have called lake Hudson-Champlain, dammed on the north by the retreating ice-sheet and held somewhat above the sea level by a greater elevation of the land at the mouth of the Hudson and southward. The submarine continuation of the Hudson river channel is submerged only 200 to 250 feet for a distance of nearly ninety miles southeastward from Sandy Hook, and I believe that this area during the Champlain epoch was a land surface across which the Hudson river outflowed from the glacial lake of the Hudson and Mohawk valleys, and later from lake Iroquois when the departure of the ice east and north of the Adirondacks allowed these lakes to become united.

A seesaw movement during the Recent epoch, uplifting the land at the north and depressing it at the south, has given to the deltas of the Hudson and Mohawk their increase in altitude from south to north, and has raised the old sea shore at Montreal to a hight of more than 500 feet; while the channel of the Hudson has been carried down so that the sea now sends its tide to Albany, the sinking of the mouth of the river at the Narrows having been at least 100 feet, according to Merrill, and the subsidence farther southward along the submarine channel probably 200 to 300 feet. This movement indeed appears to be still continued on the New Jersey coast at the present rate of perhaps two feet in a hundred years.

WARREN UPHAM.

Somerville, Mass., May 9, 1892.

PERSONAL AND SCIENTIFIC NEWS.

REPORT OF A COMMITTEE ON THE CLAIMS OF WILLARD GLAZIER.

ST. PAUL, MINN., May 9, 1892.

To the Executive Council of the State Historical Society of Minnesota.

The special committee appointed by you to consider the communication of Capt. Willard Glazier relative to his alleged discovery of the true source of the Mississippi river, has to report as follows:

1st. His charts are hydrographic and topographic misrepresentations.

2d. His claim that among his assistants were noted geographers and expert engineers, is a bold fiction apparently devised to mislead the credulous.

3d. Many of his assertions are willful perversions of well established geographic and historic facts, and others betray a

gross, and in the light of his claims, culpable ignorance concerning the country surrounding the head waters of the Mississippi.

4th. In tone, Capt. Glazier's statements are discourteous to this society and its representatives; to the faithful living engineers and explorers who preceded and followed him; and a dishonor to the memory of Morrison, Schoolcraft, and Nicollet.

5th. Throughout, Capt. Glazier, as on all other occasions when he has discussed this matter, seems by reason of vanity, and a desire for commercial profit to seek a cheap notoriety, the only thing in the light of real discoveries and explorations that is left to him.

For the reasons cited, your committee would respectfully recommend that the communication of Capt. Glazier be tabled as in every sense unworthy of your adoption.

Signed { T. H. KIRK, J. V. BROWER, N. H. WINCHELL.

THE OHIO ACADEMY OF SCIENCE, organized at Columbus, Dec. 31, 1891, will hold its Summer or Field meeting, June 3 and 4, at Akron, in the valley of the Cuyahoga, the guest of the Akron Scientific club. The president is E. W. Claypole, and the secretary is W. R. Lazenby.

THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS will have a field meeting at Green Lake, six miles from Ripon, Wis., June 2, 3 and 4, diversified by various scientific excursions, and by a literary program. Announcement is made by the secretary, Prof. W. H. Hobbs.

MR. GEORGE H. BARTON spoke on the evening of April 20th before the Boston Society of Natural History on the progress made during last year in his work for the U. S. Geological Survey in mapping the drumlins of Massachusetts. The number already mapped exceeds 1,100, and it is estimated that the whole number of these drift hills in the state is about 1,500.

PROF. I. C. RUSSELL, of the U. S. Geological Survey, has been appointed to the professorship of geology at the University of Michigan, long held by the late Alexander Winchell.

THE LEGISLATURE OF THE STATE OF NEW YORK has appropriated eighteen thousand dollars to carry forward the paleontological work of the Geological Survey, providing for the publication of Vol. VIII of the paleontology of the state; also five thousand dollars "for the completion and publication of the geological map of the state of New York, under the supervision of the state geologist, and in co-operation with the director of the United States geological survey;" also two thousand dollars to obtain records and specimens of the deep shafting by the Livonia Salt company.

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